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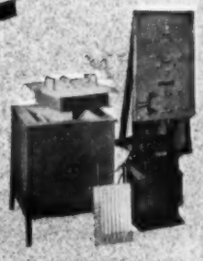

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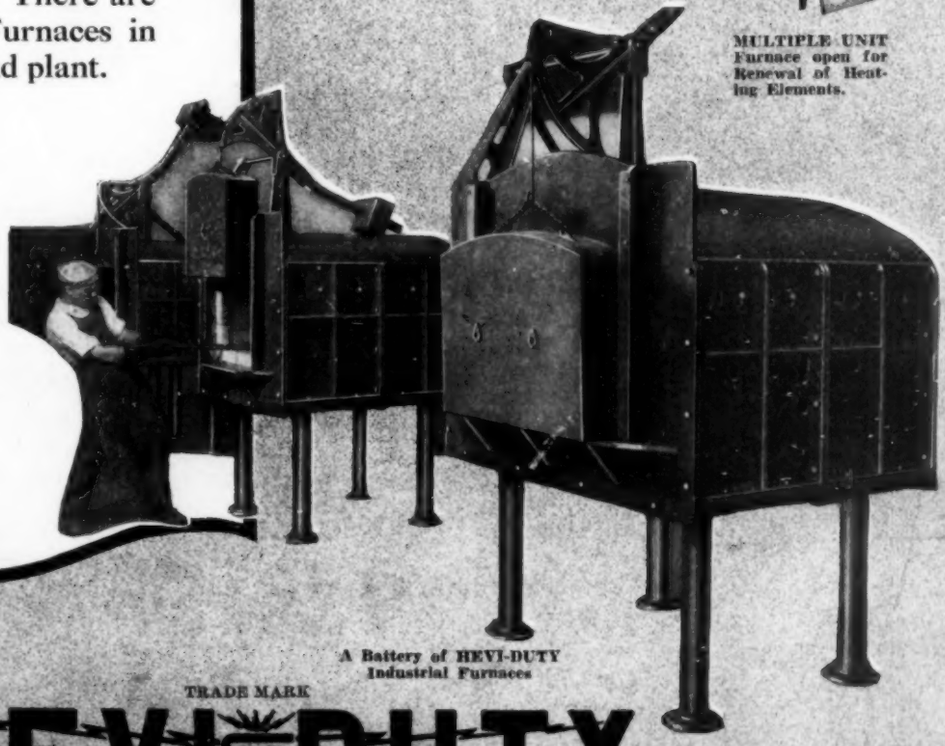

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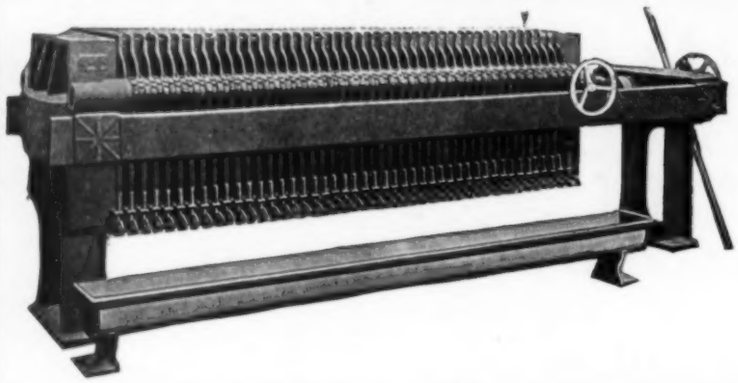

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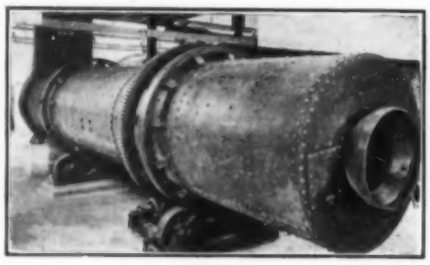

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CHEMICAL & METALLURGICAL ENGINEERING

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Coal, and the Rocky Road To Normalcy

STRIKES at hand and in prospect! Wars and rumors of wars! Peace that Senates will not ratify!

Such is our topsy-turvy world, a psychological maelstrom which keeps nations arming against they know not what, industries filling their stocks to withstand a state of siege, and the individual hoarding necessities against the hour of trouble. Such obstructions beset the return of sanity in us all.

The recent conference on unemployment emphasized how intimately the mental outlook affected everyday affairs. Almost everyone can see that slow trade and few jobs are cause and effect, and effect and cause; but we need to be reminded that the very realization of slow trade and a vision of jobless men intensifies that very condition. "Millions of people out of work! When will it hit me? Guess I'd better go slow!"

So narrow is the ledge which separates prosperity from panic and credit from ruin that it is crossed almost over night by a wave of thought. This doubtless is the reason why men who are really conversent with conditions throughout our country, and even of the world, are very careful against spreading alarming reports unless they are absolutely justified in doing so. And in this very direction lies a great fault in our Hallowe'en bogy, the threatened railroad strike. It is perhaps unreasonable to expect labor unions to give up their most efficient weapon, the strike, but it does seem hasty to brandish tomahawks and beat the tocsin now.

Doubtless many such considerations are the underlying reason why public officials and the press have had so little to say about the coal situation. Or it may be our national business policy not to borrow trouble; not to worry much about what can be foreseen—let it arrive and then make shift. But that is certainly not the way of engineers. In their work they must visualize all probable combinations of circumstances, and provide ways and means of preventing or handling them.

So, looking beyond the present railroad scare, they should be informed that there is unquestionably going to be trouble in the coal fields next spring. Operators have already agreed to arbitrate any question of wages, but the unions in recent convention at Indianapolis stand firm on a wage increase. Undoubtedly, this means no coal next spring, either bituminous or anthracite.

With this in view, managers would be well advised, and engineers would do well in emphasizing the fact, that several months' coal should be stored *now*. Deliveries are now prompt, and will be slow after New Year's. A drop in price sufficient to cover the risk of unpreparedness cannot be expected. Furthermore, generous purchases of coal would do much to relieve one most acute spot on the unemployment map—in the bituminous coal fields.

Do it now, and help over the bumps along the road to normalcy!

Internal Strain Versus Amorphous Metal

BEILBY'S theory of amorphous metal, as later extended by various scientists, has enjoyed such widespread acceptance among American metallurgists and has been put to such good uses that we sometimes forget the fact that a strong contingent of European workers declines to subscribe to the soundness of the idea. A leader of these "dissenters" is Professor E. HEYN. His comments on JEFFRIES and ARCHER'S recent publications on the hardening theory are printed on page 728 of this issue. In order that there may be readily available a statement of what Professor HEYN considers the greatest obstacle to the theory of amorphous metal, his "Theory of Strengthening of Metals by Cold-Work" has been translated and abstracted on page 735. Unfortunately, space limitation has made it necessary that this material be highly compressed. However, a great deal of pains has been taken to avoid distortion of the original meaning, and those who are using metallurgical theory will undoubtedly study HEYN'S ideas with interest.

In denying the amorphous theory, HEYN insists that a theory of latent tensions or of internal strain can be applied directly to a single-phase alloy, a metal wholly crystalline to the smallest particle. It is therefore surprising that he finds it necessary to visualize the mechanism of the imagined actions by the use of a compound substance composed of two such dissimilar materials as steel springs and modeling clay. However, this is a remark in passing and no sound reason for dismissing the theory.

And, without inferring that BAUSCHINGER'S published results have led to incorrect generalizations, it should be stated immediately that the development of optical methods for making a continuous record of a tension or compression test has given the investigator an implement of precision with which to make a searching resurvey of the field of elasticity. Without waiting for this critical examination it is agreed that when a metal has been loaded beyond its original limit of flow and then unloaded, it retains within it a certain amount of elastic strain and a corresponding stress which is held in equilibrium by some internal force similar to frictional resistance. In other words, when a test-bar is pulled, the crystals deform very slightly in shape and size, acting in an elastic manner up to the limit of flow, when their capacity for further homogeneous distortion is exhausted and further movement takes place by slip of crystalline blocks along their cleavage planes, partly relieving the load, permitting some of the crystalline fragments to return toward their original atomic spacing temporarily. However, the great majority of the crystals continue under distortion which approaches the breaking point.

One does not need to postulate amorphous layers around the crystalline blocks to grant that when the

external load is relieved, the distorted crystals visualized by HEYN as springs must exert a certain amount of pressure against their surroundings before the bar as a whole should contract. Crystal interlocking might be called upon to explain this lag. Entire relief of external loading, in other words, leaves the crystals in possession of a small residual deformation, corresponding to an internal strain similar to that imposed by external tension. By "internal" probably everyone (even Professor HEYN) means "within the test-piece" rather than "within the space lattice," for it is not admitted that physical distortion below the elastic limit can introduce something into the relations *between* atoms which would prevent recovery of normal spacing; strained crystals are due to forces acting somewhere upon their surfaces.

If it be assumed that the residual compressive strains are so arranged that they must be relieved on a second loading before the crystalline blocks take any additional deformation, no extension of the piece will be measured until the external load is sufficient to balance the internal resistance holding the internal stresses in equilibrium. But when that time comes, the crystalline blocks of our conception, or the springs of HEYN'S, are by no means free of stress, as Professor HEYN would have us suppose when he moves the origin of his stress-strain diagram and measures internal stresses from the new position. The elastic portion of the metal retains the residual deformation it possessed before reloading, and consequently the corresponding internal stress, a stress which is in the same sense as that imposed by the second loading in tension. Hence, considering only the distortions in the crystalline blocklets, it is difficult to see how the unit stress at their limit of flow will be in any way different or located on a different abscissa in the stress-strain diagram than on the first loading. Rather it is the compression loading on the surrounding material (likened by HEYN to frictional resistance) which is relieved by the first loads applied, and whose subsequent tension stresses may be measured from the transformed axis. However, Professor HEYN denies the actual existence of any such substance in a single phase metal, although he visualizes it as a thing so non-metallic as clay.

But only for the time being! In order to explain the lowered limit of flow in compression, it is apparently necessary to have the commanding part of the material free of stress at point *D* of his diagram (page 736). Therefore the "plastic mass" which held the "springs" in tension on relief of the first tension loading suddenly transforms itself into "springs" in compression, and this is the stuff which fails first in the subsequent compression test and so extensively as to produce flow at a low load. Howbeit this stuff is non-existant.

At any rate, if Professor HEYN'S views on residual stresses in overstrained metal be accepted, his hypothetical springs in tension be replaced by the actual crystalline blocklets, slightly deformed, and these ideas be then used to explain the higher flow limit on repeated loading and a lower flow limit in opposite loading, one is led to the conclusion that the material surrounding the crystalline fragments and holding them in position must have more influence in shaping the stress-strain curve than the blocklets themselves. This is true, whether we conceive this cementing material to be amorphous metal, or, with HEYN, merely layers of atoms pulled or pushed slightly out of their crystallographic positions and existing in a state of elastic strain.

Act! but Think First

JUST because we brought out an important issue of this magazine in which we endeavored to point out where the faults lie in various chemical and metallurgical industries, we do not want to become common scolds. We want to take a cheerful view of life. But we think it worth while occasionally to look at the reverse side of some leading examples, and, without criticising the eminent men who have set them, to point out how such examples may be misused.

One of the most frequent references to the late ANDREW CARNEGIE is that he was never afraid to make a big scrap-heap if he had something better to take the place of what was discarded. The idea of that very canny and provident Scotchman, ruthlessly tearing down valuable equipment to throw it away, seems big and strong and mighty. If a thing is no good, get rid of it! Don't be afraid! It sounds fine. But unfortunately it has become the slogan of the wastrel and the man who is lazy in his mind. "Cut it out and call it a loss," we say; and then we smile at ourselves for our courage.

The other day we came across an Indiana farmer who is doing very well. He said when he took the farm over he was short of money to buy the machinery he needed, and among other things he lacked a corn planter. A neighbor had lately bought a new one and discarded his old one—which was laid out in the weather alongside of his new one. "What do you want for the old corn planter?" the young farmer asked. "It's no good," said the neighbor, "it's all used up. It's junk." "But what do you want for it?" he persisted. "I tell you it's all used up; you can have it for a dollar." So he bought it for a dollar, took it home, took it apart, oiled it and got the rust off, used it successfully for two years and then sold it for forty dollars when he needed a larger one.

Often we treat processes and whole industries just as the neighboring farmer did. They don't work and so, being ambitious to be drastic and powerful and resolute, we say: "Cut it out! Send it to the scrap-heap!" What we lack in our head-pieces is patience and persistence along with industry. We pride ourselves on thinking quickly when we don't think at all. We misuse CARNEGIE'S careful study and the superior technical information and advice with which he provided himself abundantly as a cover for our own ignorance and laziness.

These quick decisions to quit early or before a thing is determined by painstaking study and information, which are supposed to represent activity of mind and peculiar resolution but which in fact are nothing more than ignorance and bullying, are the despair of research. If a man speaks short and quick, that is no reason to believe that the activity of his mind is short and quick. He may not think at all. Very often he doesn't. He can dress his words as though he were a captain of dragoons while he uses his mind as though he ran a peanut stand.

The country is full of the corpses of enterprises that might have been going and producing concerns if it hadn't been for this loud-mouthed slap-dash impatience of ignorance. The destroyers are of the kind that declare they have no time for theories; that if you have anything that is all tried out and proved they will give it attention, but they prefer to let some other fellow do any experimenting that may be needed. And where should we all be today if nobody had ever had any use for theories or any willingness to experiment? We should be back in the woods, climbing trees!

Tinkering With Scientific Bureaus

OUR opinion has been requested regarding a scheme for the reorganization of the scientific bureaus of the Government and we cannot refrain from offering a few comments on the nature of that request. We received four closely typed pages across the first of which was written the touching appeal, "Will you please publish this in whole or in part?" while at the bottom of the last page and beneath the signature of our correspondent was the following postscript: "Please write soon to your Senator and Congressman urging this plan." The plan itself is simply this—all of the scientific bureaus of the Government are to be consolidated under one department. This idea, to be sure, is not entirely new, but in other respects the plan is not at all lacking in novelty. The suggestion of creating a new department of science is summarily dismissed, for "already there exists an institution which has great prestige and represents the science of the Government in a general way. It is the Smithsonian Institution." Just why the Institution was chosen is not exactly clear unless it is believed that bureaucratic life is now extinct and the bureaus themselves are ready for the museum!

Our would-be reformer, however, is really serious. He lists in all thirty-two scientific bureaus which, with their personnel and appropriations intact, should be transferred to the Smithsonian Institution. Among these we note the Patent Office, the Bureau of Fisheries, the Library of Congress, and even the Government Hospital for the Insane! Such is the rare combination to be effected in the interests of efficiency.

But we are told that there is appalling duplication in these scientific bureaus. For instance, the Library of the Smithsonian Institution contains 100,000 volumes, twice this many are in the Surgeon General's Office, and each of the other scientific bureaus maintains its own specialized library. Now all these libraries are to be combined under the Smithsonian Institution in order (to use the words of our correspondent) "to reduce expenses by avoiding duplication of books." Imagine the line forming on the right for consulting Vol. III of Thorpe or glancing through the pages of the latest number of CHEM. & MET.

And still there are many other reasons why this super-government control should be vested in Smithsonian. The consolidation "will tend to give more influence and efficiency to science and divorce it from the evils of politics." Furthermore, "many of the bureaus now have little influence and consequently *the scientific workers are paid shameful and minimum salaries.*" The italics are ours, for we feel that here we have struck the real keynote of the proposal. Our conviction is confirmed a little farther down in the brief, where we find the suggestion that "in inviting scientific men to take up *permanent* work with the Government, it is understood that they cannot be removed from their positions without very serious charge. . . . A true scientist in love with his work is more concerned with the permanency of his position and independence in his work than in the salary he obtains" and therefore "is always willing to make some sacrifice if necessary when the good of all Government science is at stake."

We have been asked for our opinion, and we are frank to admit that to us the scheme appears most ridiculous. It is the sort of propaganda that obscures the real issue and contributes nothing toward the solution of one of the most serious problems confronting the Government. The Congressional Joint Committee on the Reorganization of the Administrative Branch of the Government needs practical, workable suggestions and scientific societies asked to indorse such schemes as this will do well to weigh their recommendations most carefully.

Iron Industry As a Barometer

LONG ago it was said that "iron is the barometer of trade," but the barometric or prophetic character of iron demand is only partial. It obtains chiefly in connection with construction work. It is characteristic of much investment construction, the kind that looks to a long period of time for returns, a skyscraper office building being a particularly good illustration, that it is undertaken when costs are low—i.e., when general business is relatively inactive. As it requires a long time for the completion of such construction jobs and as periods of inactivity and activity alternate, the jobs undertaken when business is inactive are usually completed when business is active. Among the first contracts let is the contract for the steel, and the letting of the contract is prophetic that later workmen are going to be employed in erecting the buildings and putting on the finishing touches.

Of a totally different character, as to its connection with trade movements, is steel bought by railroads either directly or in the form of equipment. In the past the railroads have not bought much steel until business had improved and their traffic had increased. In the past one would have had to be quite blind to avoid seeing that business had improved until he observed that the railroads were making purchases on a liberal scale. The rule will apply to the immediate future. Until there is a very material increase in freight traffic the railroads will not buy freely.

In still another category is the steel that is bought directly or indirectly by the general public for current consumption, corrugated sheets, wire fence, agricultural implements, etc., by the farmer, tools by the mechanic, household wares by the housewife, and so on. This buying follows rather than precedes an improvement in business.

Some demand for steel precedes, some demand accompanies and some demand follows an improvement in general business. Only part of the steel demand is barometric or prophetic. If one wishes to obtain an indication for the future he should not take the demand for steel as a whole, but should scrutinize the steel market in detail and pick out the particular classes that are indicative along this line. The sales of Fords to farmers are one thing, the fabricated steel lettings, as reported by the Bridge Builders' and Structural Society, are an altogether different thing.

As to the divergence in conclusions reached by observation of the steel market in the recent past, that is due largely to the finished steel business having divided itself into two classes. One class includes sheets, wire products, tin plates and tubular goods. Demand for these has been and is relatively good. The other class includes bars, shapes, plates and rails. Demand for these has been and is very poor. Materials in the first class are widely distributed and the demand for them betokens a very fair degree of common everyday activity. Materials in the second class run more to construction work, investment buying and railroad buying. They make "the tonnage" in steel, and when they are in poor demand the steel output is low.

Readers' Views and Comments

The Slip Interference Theory of the Hardening of Metals

To the Editor of Chemical & Metallurgical Engineering

SIR:—I read with keen interest the important contribution by Dr. Zay Jeffries and R. S. Archer, which sheds light on many dark points, and I am glad to avail myself of this opportunity of recording some comments.

The Amorphous Metal Theory of Beilby. To my regret I am unable to sympathize with this theory, which, as the authors suggest, gives the only completely satisfactory explanation of the phenomena of the strengthening of metals by cold-work. First, I doubt whether the amorphous metal theory might justly be called a "theory" at all. In advancing a theory, a fundamental supposition is made, which by logical reasoning leads to conclusions controllable by observation.

The amorphous metal theory necessitates quite a number of independent suppositions: (1) The existence of the "amorphous" phase. (2) Different assumptions as to the properties of this phase, which is assumed to be hard, of great strength, to have fluid characteristics, to be soft at elevated temperatures and so on. In short, all the properties which can be observed in the metal itself are, as circumstances require, attributed to this hypothetical phase. Now, it is a somewhat unsatisfactory "explanation," to explain the properties of a substance as a whole by attributing the same properties to a hypothetical part of it. The amorphous theory might thus be termed a *pars pro toto* theory.

However this may be, there is a serious objection to this theory. It can explain the fact that a metal which has been stressed in tension beyond its yield point will after unloading and loading anew in tension exhibit a higher yield point, or, in other words, be strengthened. Now it is a known fact, established by the research work of Bauschinger, that a metal which has been stressed in tension beyond its yield point, has its original yield point in compression lowered, and *vice versa*. Cold-work in tension thus can effect strengthening in tension (hardening), but, on the other hand, cold-work in compression causes weakening (softening), when tested in tension. I should like to know how this well-established phenomenon could be explained by the amorphous theory without starting some new assumptions *ad hoc*.

This curious behavior of metals led me to the theory of "latent elastic strains" which is outlined in *Metall und Erz*, 1918, Nos. 22 and 23, and more completely[1] in the *Festschrift der Kaiser Wilhelm Gesellschaft zur Forderung der Wissenschaften*, 1921, p. 121, entitled "A Theory of the Strengthening of Metals by Cold-Work."

As to the boundaries between neighboring crystal grains, I am convinced that in them the arrangement of the particles of the space lattice will be different from the arrangement of the particles in the interior of the crystal grains. A field of forces will act between the surface layers of contiguous crystals and the particles will take positions along the lines of force. This forced or restrained state of the substance along the boundaries seems to me to have close resemblance to a state of elastic strain. In so far I agree with the authors that these boundaries play an important rôle in the behavior of the metal.

Provided there is no foreign matter inclosed between neighboring grains, I cannot see any necessity to suppose these boundaries to be amorphous, or liquid, or undercooled, and I oppose this view for the same reasons which hinder me from denoting by the word amorphous a crystalline substance which is slightly deformed under elastic strain.

Troostite, Osmondite, Sorbite. The authors join the very generally accepted opinion that these constituents represent nothing more than different degrees of subdivision of the cementite particles in a ferrite-like groundmass. Some years ago I called attention[2] to the maximum of solubility exhibited by steel hardened and tempered at 400 deg. C. (exhibiting a structure called osmondite) to the maximum of dark coloration on etching and to the greatest carbonaceous residue on dissolving such steel in dilute acids. Prof. Benedicks tried to explain this behavior by drawing analogies with the phenomena observed in colloidal solutions of solid bodies in liquids. But his argument, though ingenious, appeared to me somewhat unconvincing and my doubts have recently been strengthened by the magnetic experiments of Saizo Saito[3] which led this author to the conclusion that the transitional constituent "osmondite" in fact contains free carbon.

Martensite Is Alpha Iron. The authors conclude that the magnetism of the martensite suggests the presence of crystalline, magnetic (alpha) iron. Most metallographers are now inclined to believe that there is no difference between alpha and beta iron, but that the critical range A_2 is nothing more than the temperature at which alpha iron loses its magnetism on heating and regains it on cooling, without any change of phase. Now, what would happen, if, by any treatment, it was possible to conserve gamma iron below Ar_2? Could not then the gamma iron have a magnetic transition point of its own, so that the gamma iron could be ferromagnetic below some definite temperature? Indeed, Prof. Honda[4] found magnetic transformations in carbon steels at temperatures above Ar_2—that is, when the iron is undoubtedly in the gamma state.

The results of X-ray spectrometry alluded to by the authors would no doubt give valuable evidence as to this question. I look forward with the greatest interest to the publishing of the details of these experiments.

E. HEYN.

Berlin-Dahlem, Germany.

[1] Abstract of the latter article is printed on p. 735 of this issue.

[2] E. Heyn and O. Bauer, "Influence of the Treatment on the Solubility of Steel in Sulphuric Acid," *Iron and Steel Institute*, 1909, vol. 1, p. 109.

[3] "On the State of Carbide in Carbon Steels Quenched and Tempered," *Science Reports*, Tohoku University, vol. 9, p. 281 (1920).

[4] "Ueber die Warmeerscheinungen und Magnetisierungsanderungen ferromagnetischer Korper bei hoheren Temperaturen," *Science Reports*, Tohoku University, vol. 2, p. 69.

What the X-Ray Spectrometer Tells About the Structure of Solid Solutions

To the Editor of Chemical & Metallurgical Engineering

SIR:—In referring to Haakon Styri's splendid notes[1] on the paper of Jeffries and Archer[2] on "The Slip Interference Theory of Hardening," it is mainly with the idea of throwing a little light upon the matter of the space-lattice conception of solid solutions. Mr. Styri has struck upon those points in the theory which have formed the basis of most of the criticism that has come to the writer's attention.

It is undoubtedly true that the X-ray spectrometer would fail to find a small amount of cementite even if it were present in austenite as such. Indeed as the writer has shown the pattern is only faint in a white cast iron whose cementite content may be quite high. Furthermore, in examining any crystalline matter composed of iron and carbon the pattern is that of the iron atoms, substantially as if the carbon were empty space. The disparity of atomic weight is responsible for this phenomenon. Nevertheless there is great cause to regard austenite as a solid solution of carbon in gamma or face-centered iron.

Many experiments have shown that when the microscope and the equilibrium diagram indicated that a solute metal exists in solid solution in a solvent metal the X-ray spectrometer shows that the average spacings between the atomic layers have not changed (center to center) from those in the pure solvent and that the solute atoms simply replace atoms in the solvent lattice. The extent of the solubility is indeed in a sense a measure of the similarity in volume and electronic distribution of the two kinds of atoms. Thus the cube edge of the "crystal cell" of copper has not changed by the addition of 30 per cent of zinc. Beyond this amount there seems to be such force distortion in the lattice that further additions of zinc form a different lattice whose interatomic forces are compatible with stability. In different alloys this may or may not represent a compound in which a definite number of each kind of atoms forms the basis of the "crystal cell." As solute is added the volume of the solid solution naturally increases in proportion to the atomic volume of the solvent, multiplied by the number of atoms of solute incorporated.

By analogy, cannot carbon atoms replace iron atoms in austenitic iron? The writer first sought to explain the solution of carbon (regardless of state) in austenite by placing the carbon atoms in the interatomic spaces—the tetrahedra of the face-centered lattice suggesting a stable location for the supposedly tetrahedral carbon atom—but the volume increase forbids consideration of this easy solution. Indeed the suggestion that volume increases with addition of cementite to austenite supports our conception admirably.

So then, if the carbon atom in austenite were compelled to be surrounded by three iron atoms in some manner to constitute Fe_3C (or perhaps Fe_6C_2) we should certainly have a discontinuity in the austenite lattice. In the course of the same investigation in which the writer, under the direction of Dr. Jeffries, showed that manganese steel, nickel-iron and hot iron were all face-centered cubic in character, some information regarding cementite was obtained—namely, that there are spacings in the cementite lattice which could not pass through the austenite lattice. Hence even a single "crystal cell," even if it were the simplest molecule, could not diffuse through austenite and the carbon atom would have to progress by continuous distortion of the lattice, constantly divorcing its iron partners and setting up new distortion. But even by this process we have been forced to picture carbon atomically dispersed, which seems to be the point which is not looked upon with favor by those who object to the idea that the solution of cementite in iron is a true solid solution. The fact is, we must regard atoms—not molecules—as the basis of crystal structure; the bricks, if you will, that build the walls of the crystal. The bricks are not alike, but fit together to form a stable whole.

In all fairness it should be said that the author finds certain strong lines in his cementite pattern to match lines in austenite. This may indicate that austenite has stability approaching that of the compound, but it does not alter the fact that all specimens of cementite do show the same very complicated pattern with some large spacings. Frankly, the "puzzling out" of the cementite lattice progresses very slowly and is very baffling. A few large crystals of pure cementite suitable for examination by the original Bragg method would greatly facilitate a solution of its structure.

Picturing here and there a carbon atom replacing an iron atom in austenite, quenching merely permits the allotropic change, leaving the carbon atoms *in situ* in martensite. The body-centered iron lattice in martensite, marvellously fine grained, is no doubt subjected to enormous force distortion by the presence of the carbon still atomically dispersed. Carbon then, as far as itself is concerned, is very like a compressed monatomic gas and could very easily, it would seem, form hydrocarbons with the "nascent" hydrogen formed during solution by acid.

The writer does not feel qualified to discuss the other extremely interesting points in Mr. Styri's paper and has in mind merely the idea of adding possibly a few details of the atomic structure phase of the new theory.

Cleveland, Ohio. E. C. BAIN.

[1] CHEM. & MET. ENG., Aug. 24, 1921, vol. 25, No. 8, p. 313.
[2] CHEM. & MET. ENG., June 15, 1921, vol. 24, No. 24, pp. 1057 to 1067.

The Use of Inert Gas for the Prevention of Explosions

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the use of inert gas for the prevention of explosions and fires, as described by Edward F. White in the Sept. 14 issue of your journal, may I call attention to the fact that the Lewis Recovery Corporation has United States and foreign patents for the use of flue gas as a carrier for the vapors of volatile solvents used in coating, impregnating or treating fabrics or other materials?

This corporation has had solvent recovery plants embodying this principle in continuous operation for over four years with entire absence of fires and explosions. These plants are recovering solvents such as gasoline and benzene in industries in which fires have been notoriously frequent. Indeed, a fire outside the inclosed solvent-using equipment in one of these plants failed to ignite the flue gas-solvent vapor mixture within, although it destroyed everything outside. No difficulty has been encountered in operating with a maximum oxygen content of 3 per cent. This gives a factor of safety of 4, as 12 per cent oxygen is required for flame propagation in hydrocarbon vapors.

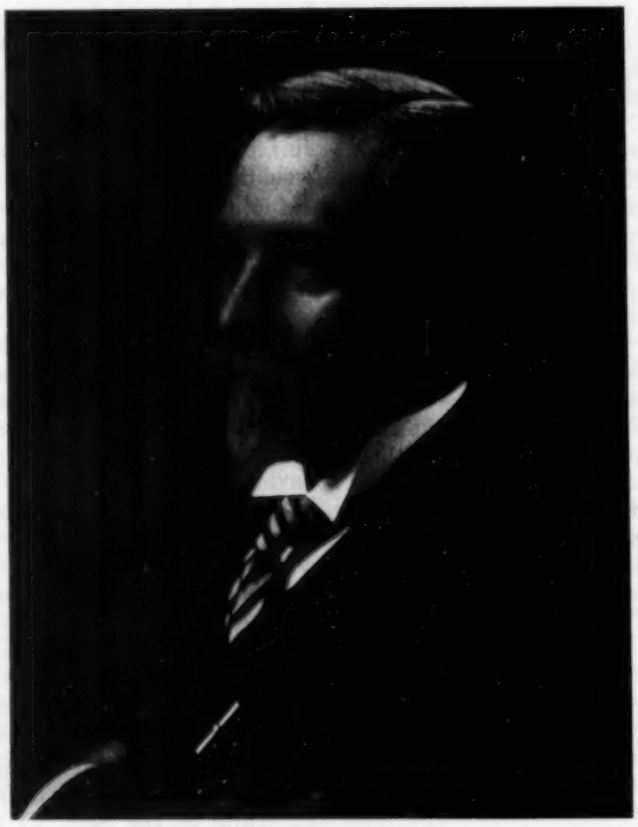
Lewis Recovery Corporation
Cambridge, Mass. KENNETH E. BELL.

Joseph William Richards

In Memoriam

DR. JOSEPH WILLIAM RICHARDS, professor of metallurgy at Lehigh University, died at his residence, 231 East Market St., Bethlehem, Pa., on Wednesday, Oct. 12, 1921, at 9 a.m., from heart failure. Impressive funeral services were held on Saturday following at Packer memorial chapel of Lehigh University, where a large number of friends, among whom were the leading chemists and metallurgists of America, gathered in honor of his memory.

J. W. Richards was born in Oldbury, England, fifty-seven years ago, on July 28, 1864, and was brought to this country when very young. He was graduated from the Central High School of Philadelphia, Pa., in 1882 with the degree of Bachelor of Arts (A.B.) and entered Lehigh University in September of that year. He was graduated from Lehigh University in 1886 with the degree of Analytical Chemist, and was awarded the degree of Master of Science (M.S.) in 1891 and that of Doctor of Philosophy (Ph.D.) in 1893. In September, 1887, Dr. Richards was appointed assistant instructor in metallurgy and blowpiping at Lehigh University, and he served continuously at the university from that time to his death in the following positions: Instructor in metallurgy, mineralogy and blowpiping, 1890-1897; assistant professor, 1897-1903; professor of metallurgy, 1903-1921.



JOSEPH WILLIAM RICHARDS

Dr. Richards was one of the foremost engineers of the country and had an international reputation in various branches of metallurgical technology. His services were widely sought as legal expert in chemical and metallurgical cases. He was a member of the U. S. Assay Commission, 1897; representative of the Franklin Institute to the International Geological Congress held in Russia in 1897; member of the jury of awards, department of chemistry, of the National Export Exhibition, Philadelphia, in 1899; member of the jury of awards and chairman of the metallurgical sub-jury, Panama Pacific International Exposition, 1915; member of the U. S. Navy Consulting Board, 1915-1918. He was a member of the Franklin Institute, Philadelphia, president of the chemical section 1897, 1899, and professor of electrochemistry of the Institute 1907-1910.

Always of an independent and original turn of mind, it was not surprising to find Richards among the "insurgents" from the American Chemical Society and the American Institute of Electrical Engineers who met in Philadelphia nearly twenty years ago to form the American Electrochemical Society; indeed, he was the first president. Many of the conservatives decried the movement, on the basis that there were enough national societies already, but the independents persisted. Since the first, the Electrochemical Society has been unique in the hearty friendliness of the gatherings, much in contrast with the habitual secrecy and reserve supposed to permeate the industry. On the other hand, the influence of example has not been without value to the tone and activities of each of the older societies. Dr. Richards' interest has been continuous. President for the first year of its existence, he became secretary in 1907, an office he has filled since that time.

A few months after the electrochemists formed their society, a small group of enthusiasts gathered together in a certain public house in Philadelphia, prominent among whom were Dr. Richards, W. D. Weaver, then Editor of the *Electrical World*, Carl Hering, and E. F. Roeber. Talk ran upon the need of a publication reflecting the aims of the new society, and it was agreed that such a magazine should be published. Unfortunately, or perhaps fortunately, the new society, numbering only 200 or 300 members, had not the funds for the venture, but Weaver promised to interest Mr. McGraw in the project, if possible. In this he was successful, and the Electrochemical Publishing Co. was formed, with Dr. Richards as president, a company which with Dr. Roeber as editor on Sept. 1, 1902, started publishing *Electrochemical Industry*, the forerunner of CHEMICAL & METALLURGICAL ENGINEERING.

Dr. Richards was no dummy president. His interest in the details of the publication was intense for several years. Furthermore, he was one of the principal editorial contributors in the first volumes, publishing many notable articles on electrometallurgy as practiced both here and abroad. His important work on Metallurgical Calculations, which has become standard and has had such a wide circulation in several languages, was published serially in *Electrochemical Industry*.

His other books include a treatise on Aluminum, and several translations, principal among which is "Cementation of Iron and Steel" from the Italian of Federico Giolitti. His contributions to the technical press and many scientific societies are legion.

Dr. Richards was fortunate in selecting teaching as a profession, and his influence on American technology, transmitted through his students, will be unending. They especially will mourn the passing of a helping friend and a true gentleman.

Studies in Colorado Shale Oils—A

Secondary Oils Obtained From a Representative Colorado Shale Oil by Successive Distillations at Atmospheric Pressure—Character and Composition of These Decomposition Products and of Their Parent Material

BY ARTHUR J. FRANKS

IN TWO recent preliminary papers[1] under this title the author presented elementary data on a number of Colorado shale oils and their fractions. The results of this work have shown that the heavy fractions of these oils are unstable and crack easily on distillation at atmospheric pressure. The decomposition is attended by the following very marked phenomena: (1) a lowering in specific gravity; (2) an increase in saturated hydrocarbons; and (3) a considerable loss of nitrogen and sulphur, as well as a decided change in their distribution. The increase in saturation was accounted for by the decomposition of the heavy, unsaturated and unstable compounds containing sulphur and nitrogen, and perhaps oxygen. But since such a phenomenon is not in accord with the theories and results prevalent in petroleum practice and because the evidence already presented was not conclusive, it was decided to extend the scope of these preliminary investigations in order to obtain further data, either in support of or in contradiction to the theories already suggested.

Scope of the Present Investigation

The purpose of the present work was to study, by means of careful analyses, the changes produced in the fractions of a representative Colorado shale oil by repeated distillations at atmospheric pressure, to endeavor to verify previous data with the hope of proving conclusively that new saturated hydrocarbons were formed as a large portion of the products of cracking and that their source was the heavy compounds soluble in concentrated sulphuric acid, and, if possible, to throw further light on the general character and composition of these decomposition products and their parent material.

This investigation was conducted along the same general lines as in the previous studies.[2] Two series of distillations were made. The first involved four successive distillations of a single sample of oil into 10 per cent fractions. The changes in these fractions were determined by the means of measurements of specific gravity, saturation, temperature of distillation and amount of decomposition, and by analyses for sulphur and nitrogen. On the basis of the behavior of the oil, as determined by these changes in the 10 per cent fractions, conclusions are to be drawn as to some of the general characteristics of the oil as well as its probable composition. A second series of distillations and analyses were made on another sample of the same oil to prove definitely that saturated compounds formed a large part of the products from the cracking of some of the heavy, unsaturated and basic fractions, to provide a sufficient amount of cracked distillate for examination and to serve as a general check on the first part of this work.

[1] CHEM. & MET. ENG., vol. 24, No. 13, March 30, 1921, p. 561 and vol. 25, No. 2, July 13, 1921, p. 49.

[2] *Loc. cit.*

The oil upon which this investigation was made was chosen because it was regarded as representing a typical product from Colorado shales of the De Beque region. It was made in a Ginet retort and was obtained through the courtesy of the Monarch Shale Oil Co. A 1-gal. sample was taken from a 10-gal. can of this oil which had been allowed to stand undisturbed in the laboratory for two weeks in order to permit most of the suspended water to settle out. The sample was thoroughly mixed by long shaking and a 4-oz. portion withdrawn for analysis. The results of this analysis are:

Specific gravity	0.909	Nitrogen, per cent	1.992
Saturation, per cent	20.8	Water, per cent	0.13
Sulphur, per cent	0.72	Initial boiling point, deg. C.	70

Outline of the Investigation Procedure

All distillations were made in Pyrex distillation flasks at a rate which was maintained constant throughout the progress of the distillation by constant and extremely careful regulation of the gas flames. Naked flames from Meeker burners were used as the source of heat. The sizes of all fractions are expressed on the basis of the original oil volume and not that of the oil distilled. The vapor temperatures were measured by a 400 deg. C. thermometer and are uncorrected for the emergent stem. The same one was used for all distillations in order that the results might be strictly comparative.

All specific gravities are expressed at 25 deg. C. and were obtained from the Baumé values taken with a hydrometer. The conversions were made from standard tables. The same hydrometer was used for all the determinations.

The water, initial boiling point (i.b.p.), saturation, nitrogen and sulphur were determined as described in former papers.[2] A modified Kjeldahl method was used in obtaining the nitrogen and a modification of the Parr sodium peroxide fusion method for the sulphur. All analyses of the crude oil and fractions were made in duplicate with extreme care. Where the results failed to check within reasonable limits the analyses were repeated and averages taken as the true values.

Method of Procedure for the First Series of Distillations

In the first distillation it was attempted to separate the oil into 10 per cent fractions with as little decomposition as possible without resorting to the use of either a vacuum or steam. A 1,500-c.c. portion of the well-mixed sample was distilled to dryness from a weighed 2-liter distillation flask at a rate of about eight drops a second. When the vapor temperature reached 300 deg. C. hydrogen gas (obtained from a cylinder) was introduced slowly in five fine streams through a perforated tube which extended to the bottom of the flask.

[2] *Loc. cit.*

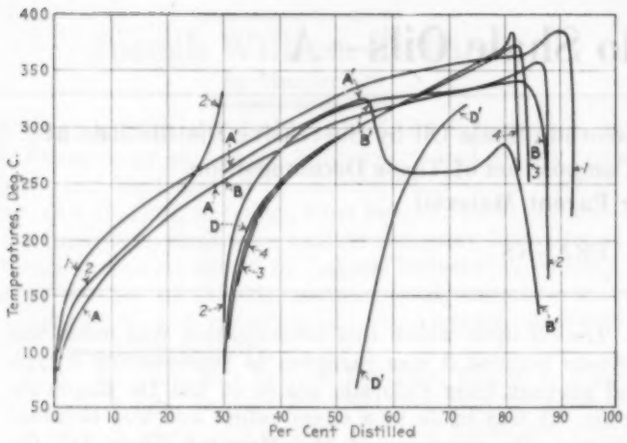


FIG. 1. TEMPERATURE CURVES

As the distillation continued, hydrogen was admitted at an increasing rate, which reached about 25 liters per 100 c.c. of distillate near the end. The rate of heating and the amount of hydrogen used were so controlled that no appreciable amount of vapor issued from the condenser. After the distillation was finished the flask was cooled and weighed. The increase in weight gave the amount of coke produced by decomposition of the oil.

Two composites were then made from two-thirds (100 c.c.) of each of the 10 per cent fractions; one contained the first three and the other the last seven fractions. The remaining portions of each fraction were then analyzed. The results appear under "1" in Table I.

Distillation of the Composites

The two composites were then distilled separately to determine their stabilities. It was also desirable to remove the lighter oils in order that the changes in the heavy oils might be more marked. The result of such procedure will be obvious from a glance at the curves in Figs. 1 to 4.

The 300-c.c. light oil composite was again distilled at a constant rate from a 500-c.c. distillation flask into three 10 per cent fractions of 100 c.c. each. The last fraction contained only 98 c.c., since it was impossible to drive over all of the oil. This introduces no appreciable errors in the analysis, however. The same analyses as before were made on each fraction. The results are given under "2" in Table I. No further distillations of the light oil were made, since changes other than those due to refractionation are not apparent. The remainder of this part of the investigation was conducted on that portion of the oil above and including the 40 per cent fraction.

The heavy oil composite (623 c.c.) of the seven fractions from "1" was distilled from a weighed 1,000-c.c. distillation flask into 10 per cent fractions of 100 c.c. each. The distillation was carried to dryness, at a rate of two drops per second, as described in a former article.[4] The weight of coke was obtained from the difference in weight of the flask before and after distillation. Three-tenths (by volume) of each of the cuts

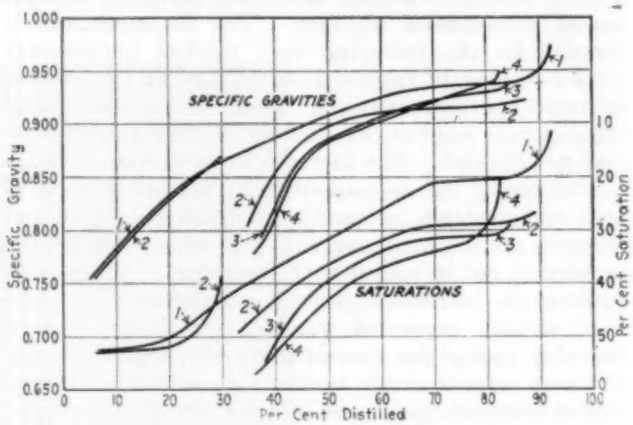


FIG. 2. SPECIFIC GRAVITY AND SATURATION CURVES

were reserved for the usual analysis, the results of which are presented under "2" in Table I.

The remaining seven-tenths of each of the fractions from "2" (405 c.c.) were composited and distilled to dryness from a weighed 1,000-c.c. distillation flask at approximately the same rate and in the same manner as before. Ten per cent fractions (70 c.c.) were again taken and the coke determined. Three-sevenths of each

[4] *Loc. cit.*

TABLE I. DATA FROM FIRST SERIES OF DISTILLATIONS

Analyses for 10 per Cent Fractions

Dist. No. Fraction	Sp. Gravities (25 Deg. C.) 1	2	3	4	Per Cent Saturation 1	2	3	4	Per Cent Sulphur 1	2	3	4	Per Cent Nitrogen 1	2	3	4
10	0.782	0.778	.....	.....	52.2	53.4	....	....	0.75	0.68	....	....	0.599	0.528	.....	.....
20	0.831	0.828	.....	.....	50.0	52.0	....	....	0.79	0.73	....	....	0.993	0.930	.....	.....
30	0.864	0.871	.....	.....	43.0	38.8	....	....	0.77	0.86	....	....	1.331	1.450	.....	.....
40	0.887	0.853	0.819	0.810	37.2	43.0	52.2	53.0	0.75	0.70	0.61	0.60	1.429	1.218	1.071	1.063
50	0.906	0.897	0.884	0.883	31.5	36.4	39.5	43.0	0.73	0.69	0.65	0.64	1.575	1.506	1.613	1.607
60	0.926	0.911	0.906	0.903	26.3	32.0	33.8	37.0	0.68	0.64	0.62	0.60	1.712	1.797	1.786	1.785
70	0.935	0.915	0.922	0.921	21.1	29.0	31.4	33.8	0.67	0.60	0.58	0.58	1.726	1.828	1.878	1.883
80	0.937	0.918	0.930	0.938	20.5	28.8	31.0	29.1	0.65	0.48	0.55	0.52	1.744	1.849	1.964	1.988
82.6	.....	.....	.....	0.950	....	....	....	19.8	....	....	....	0.47	.....	.....	.....	2.169
84.3	.....	.....	0.937	.....	....	....	28.6	....	....	....	0.45	....	.....	.....	1.992	.....
87.9	.....	0.924	.....	.....	....	26.8	....	....	....	0.40	....	....	.....	2.037	.....	.....
90.0	0.950	.....	.....	.....	17.0	....	....	....	0.60	....	....	....	1.832	.....	.....	.....
92.3	0.975	.....	.....	.....	11.0	....	....	....	0.52	....	....	....	2.084	.....	.....	.....
Composite*	0.924	0.903	0.894	0.892	25.1	32.9	36.9	37.3	0.67	0.59	0.59	0.58	1.688	1.700	1.706	1.707

Vapor Temperatures

Dist. No. Fraction	Temperature, Deg. C. 1	2	3	4	Dist. No. Fraction	Temperature, Deg. C. 1	2	3	4
0	70	65	...	...	80.0	360	342	365	370
5	182	158	...	...	81.5	...	...	...	385
10	205	179	...	...	82.0	...	...	...	360
15	...	204	...	...	82.1	...	...	370	...
20	245	229	...	...	82.6	...	...	...	260
25	...	257	...	...	83.6	...	...	340	...
30	276	330	§65	§65	84.3	...	...	250	...
35	...	†245	207	208	86.5	...	358	...	...
40	302	278	250	247	87.9	...	165	...	...
50	330	316	289	288	90.0	385	...	...	...
60	344	326	315	317	92.3	220	...	...	...
70	355	332	340	340					

* Compo ite of heavy oils from fractions over 30 per cent. † First drop in receiver, 135 deg. § Initial boiling point.

of these cuts were withdrawn and the same determinations made as for the other fractions. The results of the analysis appear under "3" in Table I.

The four-sevenths of the oil remaining from each of the "3" fractions (217 c.c.) were composited for the last time and distilled into 10 per cent fractions (40 c.c.) from a weighed 500-c.c. distillation flask. The rate of distillation was maintained at about three-fourths of a drop per second. The usual data were obtained on these fractions. The results are given under "4" in Table I.

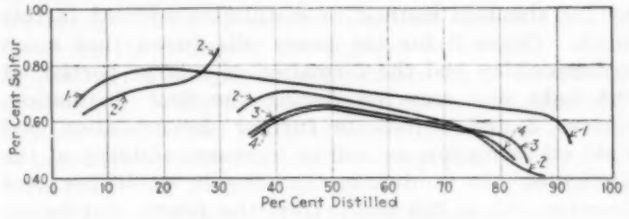


FIG. 3. SULPHUR CURVES

Method of Procedure for the Second Series of Distillations

The second series of distillations was carried out in a somewhat different manner. A 1,200-c.c. sample of the same oil was distilled from a 2-liter flask at a rate of four drops per second until 30 per cent (360 c.c.) had been condensed. The resulting fraction will be called "*A*" for the sake of convenience. The distillation was then stopped, the undistilled residue (hereinafter designated as fraction "*B*") allowed to cool, and a sample then withdrawn for analysis. A 490-c.c. portion of this residue was then distilled to dryness from a weighed 1,000-c.c. flask at a rate of two drops per second. The weight of coke was obtained by weighing and subtracting the weight of the cold flask. Vapor temperatures were read at every 5 per cent fraction, but no cuts were made. The whole distillate (hereinafter designated as "*C*") was then thoroughly mixed and a sample taken for analysis.

The heavy unstable oils present in *B* must have decomposed during this distillation, and whatever light oils were thus formed therefrom must have been left in *C*. Hence, 330 c.c. of *C* was then distilled from a 1,000-c.c. flask at a rate of two drops per second. As the vapor temperature reached 250 deg. C. the distillation was slightly retarded in order to permit a sharper separation of the oil boiling below 254 deg. C., at which temperature the distillation was discontinued. This distillate will be hereinafter referred to as "*D*" and the residue as "*E*." Obviously, *D* is a new, secondary product formed by the cracking of certain constituents originally present in *B*.

Determinations for specific gravity, saturation, sulphur and nitrogen were made on *A*, *B*, *C*, *D* and *E*. All analyses were made in duplicate. In addition to these analyses, determinations for aromatics and organic bases were made in *A* and *D*. The data from these analyses are given in Table II. The temperature curves are presented, together with those from the first series of distillations, in Fig. 1.

The aromatics were determined by the "aniline point" method developed by Tizard and Marshall.[5] It depends upon the difference between the temperatures of mutual solubility of saturated hydrocarbons containing aromatics, and of those free from such compounds.

[5] *J. Soc. Chem. Ind.*, 40, 20T, 1921.

TABLE II. DATA FROM SECOND SERIES OF DISTILLATIONS

Analysis of Fractions

Product	Yield, per Cent	Sp.Gr.(25° C.)	Sat., per Cent	Sp.Gr. Sats.	Sulphur, per Cent	Nitrogen, per Cent	Aromatics, per Cent	Bases, per Cent	Unsat. Compds.
A(70–254°)	30	0.824	45.6	0.809	0.72	1.034	4.7	8.0	46.4
B	70	0.950	11.5	.....	0.66	2.336	...	....	....
C	57.1	0.905	32.5	.....	0.60	1.880	...	....	....
D(75–254°)	10.8	0.826	49.2	0.791	0.64	1.164	2.8	12.0	38.8
E	46.2	0.924	29.0	.....	0.58	2.055	...	....	....

Vapor Temperatures

Product	Per Cent Fraction	Temp., Deg. C.	Product	Per Cent Fraction	Temp., Deg. C.	Product	Per Cent Fraction	Temp., Deg., C
A	5	140	*C*	35	265	*C*	80	339
	10	172		40	280		82	341
	15	195		45	292		85	335
	20	218		50	303		87.1	250
	25	236		55	312			
	30	254		60	317	*D*	5	218
				65	324		9	242
				70	330		10	250
				75	335		10.8	254

It was first necessary to remove from the sample to be analyzed all bases and unsaturated hydrocarbons by means of a thorough treatment in the cold with a liberal amount (about 200 per cent by volume in all) of 95 per cent sulphuric acid. The saturated hydrocarbons were allowed to separate, the tar was drawn off, the hydrocarbons poured into a small clean flask, and then carefully washed with a very small amount of water. Powdered anhydrous sodium carbonate was then thrown in to neutralize any acid remaining in the oil and to take up the water. After standing for about a day the oil should be neutral, clear and dry. An ordinary washing

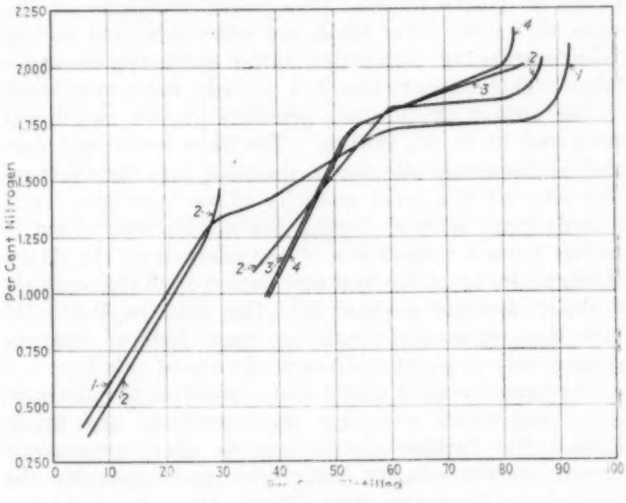


FIG. 4. NITROGEN CURVES

with either water or alkali solution should not be attempted in the case of shale oil distillates, since persistent emulsions are formed which are separable only with great difficulty.

After obtaining the specific gravity, the aniline point was then determined on the saturated hydrocarbons by measuring a 10-c.c. portion into a large test tube from a pipette, adding 10 c.c. of freshly distilled aniline from another pipette, heating and stirring the mixture until complete solubility obtained, then slowly cooling and stirring and determining the temperature at which it became turbid. This temperature is the aniline point.

The remainder of the saturated oil was then sulphonated by shaking in the cold with a liberal amount of 98 per cent sulphuric acid for about 20 to 30 minutes, which treatment removes the aromatics. The hydro-

carbons were then separated, washed and dried as before, and the aniline point determined. The percentage of aromatics by weight was obtained from the difference in aniline points by the use of a curve prepared by Tizard and Marshall.[6] Since the saturation and specific gravity of the oil and the specific gravity of the saturated hydrocarbons were known, the percentage by weight of aromatics in the original sample was easily calculated.

The bases were determined by measuring the absorption of the oil by dilute hydrochloric acid. Ten c.c. of the oil was measured into a graduated 15-c.c. centrifuge tube and 3 c.c. of HCl (1 part conc. acid to 4 parts of water) added. The tube was stoppered, well shaken and centrifuged until separation of the two liquid layers was complete. From the amount of oil absorbed by the acid the volume per cent of bases was calculated.

The unsaturated compounds are expressed in per cent by volume and were calculated as the difference between 100 and the sum of the bases and saturated hydrocarbons.

Facts Deduced From the Tabulated Data and Graphs

The data presented in the tables and represented graphically by the curves verify the results of previous work, as well as many expectations. In general it may be said that the light oils (boiling below 270 deg. C.) are very stable and suffer no appreciable alterations on distillation other than those due to changes in distribution of some of the compounds obtained by a higher degree of fractionation. The heavy fractions of the crude oil, on the other hand, are not stable, and during a single cracking distillation suffer extensive decomposition. This phenomenon has already been mentioned by the author in the two previous papers mentioned above and by C. W. Botkin.[7] The very heavy end portions of the crude oils are so unstable that they decompose even when a large quantity of an inert gas (such as hydrogen) is used during the distillation. This is obvious from a comparison of the analysis of the heavy oil composite from the first distillation with the analysis of the undistilled residue *B*. The data in Table III show that, generally speaking, about half of the unstable constituents of the heavy oils are of this type.

After one cracking distillation, however, the oils produced and those escaping decomposition are fairly stable.[8] Yet further distillations do effect appreciable changes in the oils, as the curves and especially the calculations from the data (Table III) show.[8] At the end of four distillations the heavy fractions (above 270 deg. C.) of the crude oil, with the exception of saturated hydrocarbons, had decomposed to such a great extent that the resultant distillates seemed to be virtually new oils, composed largely of products from the cracking of those fractions. It will be shown later that this is actually the case.

The temperature curve (Fig. 1) constitutes a valuable index of the general course of the changes produced in the oils by the successive distillations. The temperatures at which 10 per cent cuts were made are plotted as ordinates and the per cent distilled as abscissas. These and all curves are drawn through the mean values wherever the points fail to strike a smooth curve. In most cases, however, the curves pass through the points determined experimentally. The curve for the first distillation lies above the others because of the great rate at which the liquid was distilled in the attempt to prevent decomposition as far as possible; hence the fractionation was poor. This is verified by curve 2 for the second distillation of the light oil. The curves for the products *A* and *C* are representative of results secured by the standard method[9] of distillation adopted in this work. Curve 2 for the heavy oils shows that much decomposition and the formation of a large portion of the light oils occurred during the first distillation. Curves 3 and 4 indicate further decomposition and light oil formation, as well as increased stability of the distillates. It is obvious that the 30 to 46 per cent fraction (65 to 276 deg.) from the fourth distillation consists of oils produced by the cracking of unstable constituents of the crude and not present originally therein.

The specific gravity curves (Fig. 2) merely confirm the conclusions drawn from the temperature curves.

The curves in Fig. 2 representing the distribution of saturated hydrocarbons show marked resemblance to the specific gravity and temperature curves. This verifies the qualitative relationship stated by the author[9]—namely, that the percentage saturation of the 10 per cent fractions decreases as their specific gravities and vapor temperatures increase. This relationship is well illustrated, especially by the curves for those fractions near the end of the distillations.

TABLE III. PERCENTAGE LOSSES AND INCREASES IN SATURATION OF DISTILLATES

Kind of Loss	Distillation 1	2	3	4	Total 1–4	*B–C*
Total weight	9.20	5.91	3.97	1.82	20.90	16.3
Coke	4.15	3.69	1.40	0.28	9.52	8.5
Gas	5.05	2.22	2.57	1.54	11.38	7.8
Sulphur	11.6	12.2	3.4	2.0	29.2	25.5
Nitrogen	32.8	4.7	3.3	1.4	42.2	32.3
Volume	7.7	4.4	3.6	1.7	17.4	12.9
Increase in sat., c.c.	93.0	34.0	10.0	—4.0	133.0	106.0
Increase in sat., per cent.	44.7	16.1	5.0	—2.0	63.8	51.0

The sulphur curves in Fig. 3, in which the percentages of sulphur are plotted as ordinates and percentage distilled as abscissas, certainly confirm the results of and conclusions drawn from previous work relative to the distribution of sulphur and its relation to various properties of the distillates. They are very similar in form. This is all the more remarkable when it is considered that all of these curves either pass through or strike very close to the points determined by analysis. In no case are the differences greater than possible errors in the analyses themselves. The data and curves confirm the deductions arrived at in the preceding paper—namely, that the cracking causes a considerable loss of sulphur, but only a small lowering of the percentage in the resulting products, and that if most of the cracking is prevented the sulphur decreases regularly in the heavier distillates, as a part of curve 1 shows. Since decomposition began after the 80 per cent fraction, the balance of the curve is forced downward. The small difference between curves "3" and "4" indicate that although most of the cracking had occurred in the first two distillations there is still a little decomposition even

[6] *Ibid.*, 22T.

[7] Chem. & Met. Eng., vol. 24, No. 20, May 18, 1921, p. 876.

[8] Botkin (Chem. & Met. Eng., vol. 24, p. 879) states: "Compared with the first distillation, the decomposition during the second and third distillations is very slight, occurring only at higher still temperatures when the distilling flask is nearly dry and probably at a temperature exceeding that indicated by the thermometer. This shows a high stability for the heavy portions of the once-run oils . . . . ."

[9] Chem. & Met. Eng., March 30, 1921, p. 561.

after a third distillation. The amount of sulphur lost by the fourth distillation is, however, not great (see Table III), which shows that most of the unstable sulphur compounds had been decomposed in the first distillations and that the new compounds and those remaining are quite stable. The fact that all the sulphur curves turn downward near the end shows that the very heavy, last oils contain a little less sulphur than the less heavy fractions.

The nitrogen curves in Fig. 4, in which the percentages of nitrogen are plotted as ordinates and the percentages distilled as abscissas, are a great aid in following the course of the changes in the oils. Since the amount of nitrogen is relatively high, determinations can be easily and accurately made, and especially because most of the heavy nitrogen compounds seem to be sensitive to heat and easily decomposed. The curves furnish further evidence in support of the conclusions drawn from the data in the preceding paper relative to the distribution of the nitrogen and the forms in which it occurs, and also confirm the deductions from the other curves presented in this communication.

It is rather surprising to find the distribution of the nitrogen so consistent and the changes in distribution so abrupt. The persistence of straight lines which represent uniform increases in nitrogen at four different rates in the distillates cannot be ignored, although their significance is not clear. The curves suggest the presence of four different series, or classes, of nitrogen compounds. No other explanation seems possible for these sharp turning points in the curves and for the uniform rates at which the nitrogen increases in the different fractions. Most of the nitrogen in the fractions boiling up to 300 deg. C. is present in the form of basic compounds, since but little nitrogen is left in these distillates after a treatment with dilute hydrochloric acid. Much basic material is also present in the heavy oils, but a large amount of the nitrogen seems to be present in the form of heavy oils containing sulphur and resembling the heavy fractions of asphaltic petroleum. Some of these nitrogenous, asphaltic oils seem to be quite stable, but the others (which are heavier) are not. This accounts for three main classes of compounds. Since there must be more than one class of nitrogen bases, the presence of a fourth series is almost certain. Many others may be present in such small amounts, or they may be distributed throughout the oil in such a manner as not seriously to effect the general distribution of the nitrogen.

Part B of this article will be published in a subsequent issue.

Cement Industry in the Philippines

The town of Naga, in the Island of Cebu, is now conceded as the best field for a cement industry in the Philippines, according to the Bureau of Science, Manila. Both the chemical and grinding tests on raw cement material produced in the field have been highly successful and point to the feasibility of a cement venture on a large scale.

The field is situated near coal mines from which a suitable supply of fuel may be run to the cement plant by gravity.

The National Cement Co., mostly owned by the Government, will in a short time erect a cement plant in this locality, it is reported.

Strengthening Metals by Cold-Work

BAUSCHINGER'S numerous experiments on cold-worked metals proved that if a test-piece be overstrained in tension beyond the original elastic limit, $+\sigma_s$, it thereby acquires a higher elastic limit in tension, but a lower elastic limit, $-\sigma_s'$, in compression (and *mutatis mutandis*). Thus cold-work in tension strengthens in tension but weakens in compression, and *vice versa*. In general the original properties return after heating beyond a "temperature of restoration," varying with the metal. In tin and lead, for instance, it lies near atmospheric. (Such metals are excluded from consideration in what follows, since working at ordinary temperatures causes no change in properties.)

Prof. E. Heyn attempts to explain the nature of these changes.[1] He says that deformation may be elastic or plastic. Within the limits of elasticity, the outer forces are balanced by those set up by the small displacements of the "smallest particles" (Heyn does not call them atoms or molecules) from their mean positions in the space lattice. Release of stress is accompanied by regeneration of the work of deformation, and the process

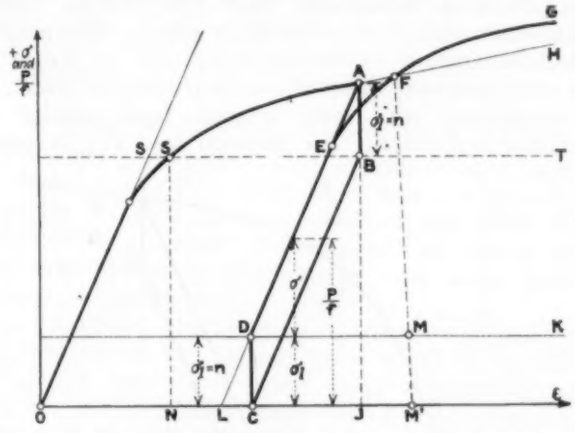


FIG. 1. IDEAL STRESS-STRAIN DIAGRAM ON RELOADING IN TENSION

is reversible. True plastic deformation is visualized by Prof. Heyn thus: Materials stressed beyond the "limit of flow" act like clay, the tiny particles migrate from one position of stability to another, and yet another. Continual flow takes place without increase of stress; increasing the force only increases the rate of flow. Release of force causes no restoration of shape or energy; the process is not reversible.

Under these suppositions an ideal stress-strain diagram should start from the origin and rise straight (by Hooke's law) to the elastic limit, (*OS'* in Fig. 1) then proceed horizontally along *S'T* to fracture. However, the actual diagrams are essentially different. The proportional limit is reached before the "limit of flow," and the latter is accompanied by no sharp break in the curve at *S*, only a very small radius of curvature, except with the iron alloys and a few others. Prof. Heyn says this early deviation from elastic behavior is due to true plastic deformation at defects and minute cavities acting as internal notches. Once the limit of flow is passed, added stress must be imposed to continue the elongation, even up to fracture, as shown by the curve *SA*, because in metals the deformation is accompanied by rupture of the crystallites into

[1] *Metall und Erz*, 1918, Nos. 22 and 23, and *Festschrift der K. Wilhelm Gesellschaft zur Forderung der Wissenschaften*, 1921, p. 121.

smaller blocklets; the body of these still act in an elastic manner, even though they are sliding past each other at their boundaries as in true plastic deformation, therefore added loads must be imposed to overcome the elastic resistance of the blocklets still remaining intact. He insists that such phenomena can occur in a pure metal containing but a single phase.

If a tension test-piece is stressed somewhat beyond the limit of flow, say to point *A* (Fig.1), and the load removed, a certain amount of contraction *CJ* may be measured, a quantity which varies somewhat with the speed of release and upon aging. The permanent set *OC* determined immediately may therefore consist not exclusively of plastic deformation, but in small part of elastic deformation held latent by internal forces.

Reloading for a second time, it is found that the limit of flow has increased. Yet if the permanent set consists entirely of plastic deformation, it would seem that the smallest particles should have returned on unloading to their original distances between mean positions, and apparently should require the original stress to restart plastic flow, and not resist a somewhat larger one. Hence Heyn returns to the assumption given in the preceding paragraph, that overstrained metal retains in addition to much pure plastic deformation a certain amount of elastic elongation or strain ϵ_l and also a corresponding stress in tension σ_l, which is in equilibrium with some internal force similar to frictional resistance. The imposed load P/f is equal

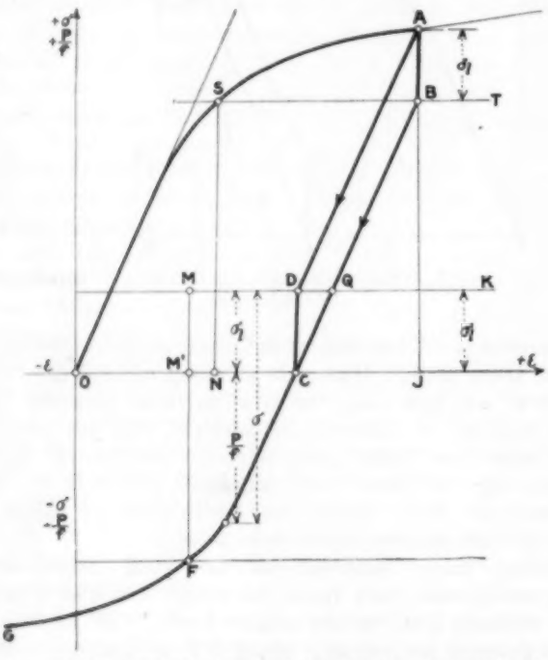


FIG. 2. IDEAL STRESS-STRAIN DIAGRAM ON RELOADING IN COMPRESSION

to the unit stress σ when the unloaded bar is free of original strain, or when release of outer load is accompanied by no latent stress σ_l. He likens the action to that of a rod of purely plastic substance like plasticene in which is embedded a multitude of fine spiral springs, which act in an elastic manner even when the piece is stressed above σ_S, the limit of flow. If this rod is rolled out, the springs attempt to return to their original position but are restrained by their anchorage.

Using these ideas to analyze the action on release of a tension test-piece loaded to a point *A* (Fig. 1), Prof. Heyn notes that at first the internal stress remains constant at σ_A (and the corresponding deformation at *OJ*) even while the imposed load P/f is decreasing. When $\sigma_A - P/f$ becomes sufficient to overcome the internal resistance w, the test-piece shortens an amount proportional to the further decrease in loading. The curve representing the relation between elongation and external load (the ϵ, P/f curve) becomes *ABC;* the ϵ, σ curve (or that between elongation and internal stress) for the corresponding time is *AD*, parallel to *BC* and separated by a constant distance, σ_l.

On reloading, the rod does not elongate until the outer force P/f becomes equal to the internal resistance counteracting the latent stress σ_l. After that, Prof. Heyn states, the rod acts exactly as it did on first loading—i.e., the curve *OSA* begins from point *D* as origin and follows *DEG*. In this the ϵ, P/f curve is *CDEFG*. The ϵ, σ curve is a parallel curve, σ_l below, or what is the same thing, curve *DEFG* with horizontal *DK* for x-axis.

The so-called strengthening, therefore, merely consists of moving the limit of flow from the load *S* to the load *F* (Fig. 1), on the original curve *OSAH*. He also believes that this strengthening is fictitious, since he measures the true internal stress σ on reloading from abscissa *DK*, and its real magnitude is the same in the second as in the first reloading. In his words: "The essential point is that the theory of latent stresses explains the loop formed by experimental stress-strain curves on repeated loadings." The form of the loop *ABCD* naturally varies with the circumstances.[2]

When loading the overstrained bar in compression, certain phenomena occur which may best be visualized by considering the overstrained bar as a complex of springs called α remaining in tension (by latent stress) and others called α' in compression (for equilibrium). Further it is assumed that a stress-strain diagram in compression would be the same shape as in tension, merely rotated 180 deg. about the origin. After release from overstrain springs α are in tension equal to $+\sigma_l$, and springs α' are in compression equal to $-\sigma_l$. As loading progresses the compression on springs α' continually increases and at *F*, the limit of flow, it is equal to $-\sigma_l - P/f$ (the distance *MF*, Fig. 2). In other words, draw a stress-strain curve in compression downward from *Q* as origin, and it will correspond to the curve derived from experiment. Such construction also shows that the hypothesis of latent stress explains why the limit of flow in compression, after an overstraining in tension, lower in numerical value than the original limit of flow in tension.

Recognizing the inconsistency of using a plastic mass to restrain his imagined springs when reloading in tension and replacing this plastic mass by springs in compression when loading in compression, Heyn imagines the latter to be incapable of taking stress except in compression. Thus they would have no influence on a second loading in tension.

Since either tension or compression causes the same kind of failure in crystalline metal—namely, by shear—the resultant deformation on cold-work is always of the same nature. By the theory of elasticity, such deformation is accompanied by an increase in volume; it has been found experimentally that cold-work of any kind is accompanied by a decreased specific gravity, according to theory.

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[2]Bouasse, Abstracts, *Ann. Chim. phys.* (series 7), vol. 29, p. 384 (1903).

Causes of High Top Heat in the Blast Furnace

Charts Recording the Temperature of Waste Gases Are of Value in Controlling Furnace Operations, Indicating Especially Clearly the Exact Time When Charging Is Done and if the Charge Is Alternately Hanging and Slipping

BY WALLACE G. IMHOFF

IT IS extremely interesting to study the operation of the blast furnace from the viewpoint of the top heat. This feature is not of minor importance, but really is deserving of careful consideration, for by thoroughly understanding the causes which effect the top heat at least one result will be smoother furnace operation.

In order to control the top heat all the conditions which effect it should be known and thoroughly understood. Some of the most important features and indications of high top heat are listed in the captions below, and discussed in some detail.

HIGH WIND

For a given set of furnace conditions only a certain volume of wind can be blown in order to maintain a state of equilibrium. If the volume of wind is decreased, then the furnace will at once respond by becoming hotter in the bottom, or if the volume of wind is increased, the furnace will at once respond by becoming colder in the bottom. Therefore a very important feature is to know just how much wind to blow into a furnace to give the smoothest operation. All these features seem so simple that they are not even important enough to bear discussion, yet in practice they are not so thoroughly understood.

Suppose, for example, we try to increase our tonnage by increasing the wind. At first perhaps there does not seem to be any appreciable difference in the operation of the furnace, but by and by the reserve heat in the furnace has been exhausted and we note as time goes on that our top heat is gradually beginning to rise.

In a short time the furnace seems to be getting cold in the bottom, although the top heat continues to remain high. As a matter of fact, with the reserve heat gone the bottom is now blown cold and the fusion zone has risen from the hearth to the mantle or higher, thus causing the continued high top heat.

LOW STOVE HEAT (COLD AIR)

One of the commonest causes of a high top heat is the continued use of cold air. At this time we generally have present an extremely hot bottom, or a bottom that is at least hotter than is desired. This would be the time to increase the wind and get more tonnage, but as a matter of fact cold air is generally run in with the stove heat to lower the hearth temperature. The cold air has two effects—it reduces the hearth temperature to such an extent that it throws the silicon into the slag as silica, and thereby frees the sulphur; and second, it raises the top heat.

The first feature may often be desired to obtain better driving, especially if the furnace is hanging, but it is accomplished sometimes only by extreme sacrifice. With the rise in top heat the furnace often gets in such a condition that it has to be slipped to put in charges. This aggravates conditions already bad and finally the furnace goes off entirely.

Cold air should seldom be used. The logical way to cool the bottom down is to increase the wind a revolution or so, and when the iron desired is made, then cut the wind back to normal. The use of cold air does not seem to be understood from another angle, and that is that it is often left on too long, throwing the furnace violently cold. Great judgment must be exercised in running the stove heat down with cold air that it be shut off before the cooling effect has gone too far.

LETTING THE FURNACE HANG A LONG TIME

It is not a good policy to let a furnace hang longer than thirty-five to forty minutes. There are a number of reasons for this, the most important one being that it precipitates too much cold stock into the hearth and lower part of the furnace at once, and hence makes extremely irregular iron.

The continued hanging of the furnace is indicated by a gradual rise in top heat. This is noted by the saw-toothed top heat curve drawn with regular furnace operation, the rise being made during the intervals of filling, and the fall being caused by the cold charge. With smooth regular driving these saw-teeth on the curve are small and there are a large number of them, for the furnace is filled often and the top heat does not have a chance to rise very high before another cold charge is put in.

The longer a furnace hangs the higher the top heat will rise. This is shown by the very large saw-teeth on the top heat chart. Once the top heat has risen to a high temperature it is often difficult to get it back to normal again. By watching the indications shown on the top heat chart under various conditions the state of the furnace can be immediately seen. For example, suppose it hangs for an hour, slips 12 ft., and then starts to hang again. The top heat chart shows a smooth continued rise in temperature, then a gradual dropping off for an hour in steps represented by the lowering of the big bell to drop in a new charge. With each charge there is a step down. Finally the furnace is filled and when the filling ceases, the top heat curve again ascends in a smooth, rising, straight line.

A COLD BOTTOM

High sulphur may be caused by a shortage of lime, but another cause of more importance is a cold bottom. The hearth temperature is the indicator of the condition of the sulphur, and, *vice versa*, the sulphur is the indicator of the hearth temperature.

The top heat chart may show a very low top heat with a cold bottom, or it may be very high. In the first

instance the stack is cold all the way up and down and therefore a top heat of 200 to 250 deg. may be expected. On the other hand, a cold bottom may be due to a high fusion zone, in which case a high top heat will be recorded. For example, suppose we show an actual case of this type. At 5:45 a.m. the bottom was cold, as shown by the analysis of the iron, 0.64 silicon and 0.078 sulphur. Thirty-two extra coke were put in at 7:50 a.m. Before the coke went in the top heat was 350 deg. By 7:40 p.m. the top heat showed 650 deg., and the bottom was still cold due to the fact that cold air was run in to counteract the effect of the coke.

As a matter of fact, the coke burned in the middle of the furnace and the bottom remained cold. By examining the iron it will be seen that when the effect of the coke disappeared the furnace was in as bad a condition as before. The complete analyses are given below:

Time	Silicon	Sulphur	
5:45 a.m.	0.64	0.078	Cold
10:50 a.m.	0.80	0.057	
3:55 p.m.	1.13	0.042	Greatest effect of coke
8:35 p.m.	1.15	0.062	
1:00 a.m.	0.80	0.052	Cold

32 extra coke put in at 7:50 a.m.
Top heat at 5:45 a.m., 350 deg.
Top heat at 7:40 p.m., 650 deg.

This example shows clearly why the lining in some furnaces is so badly cut out above the mantle. The high fusion zone is indicated clearly by the high top heat and cold bottom. The use of cold air is one of the quickest and surest ways of raising the fusion zone.

High Sulphur

As stated above, high sulphur is caused by a cold bottom. By continually observing the top heat chart other features of interest are also to be seen at this time. In addition to the high top heat and high sulphur, generally there is a high blast pressure, sticking and hanging, and slow furnace driving.

The addition of a large amount of extra coke often raises the sulphur. This is shown by an example when thirty extra coke were put in at one time. The top heat curve showed very high peaks and the iron at cast time analyzed 0.54 silicon and 0.072 sulphur. Another example is of interest, as it shows the effect very strongly in the iron and also in the extreme rise and fall of the top heat curve. At 2:30 p.m. thirty-two extra coke were put in. The complete analyses of the iron show the effect of the coke:

Time	Silicon	Sulphur	
5:45 p.m.	0.54	0.060	Cold
10:30 p.m.	1.38	0.034	Coke
2:55 a.m.	1.53	0.244	Coke
7:50 a.m.	0.37	0.207	Cold

High-sulphur iron is often made on a hot lean furnace. This also is accompanied with a high top heat. An example of such a furnace is given below. The top heat was from 400 to 650 deg. all the time:

Iron		Slag		
Silicon	Sulphur	Silica	Alumina	Bases
1.83	0.038	.....	.....	.....
1.70	0.047	.....	.....	.....
1.72	0.053	35.86	13.68	48.21
2.31	0.053	.....	.....	.....
2.22	0.067	.....	.....	.....

The silica in the slag should be about 33.00 for 13.68 alumina and 48.21 bases.

Hanging and extra coke go hand in hand. On some furnaces it is a normal thing to put two extra coke in after every slip. It is interesting to look at the effect of slipping with extra coke as seen by the top heat chart. The condition of a furnace was such that it was slipped at 5:10, 6:05, 6:10, 6:20, 7:30. Eight extra coke were put in at 8:25 a.m., eight at 12:10 p.m., sixteen at 3 p.m. and eight at 6:30 p.m. The top heat had been running along at about 350 deg. Just as soon as the extra coke took effect it raised to 400 and then to 550 deg.

Another example showing the relation of the top heat to slipping and extra coke is shown when the furnace was slipped at 12:45 a.m., 1:45 a.m., 2:30 a.m., 3:20 a.m., 3:45 a.m. and 4:35 a.m. Four extra coke were put in at 12:20, and twelve extra coke at 4 a.m. The top heat had been running uniformly around 350 deg. When the coke came down the top heat chart showed 350, 350, 400 and 500 deg. respectively.

These examples are sufficient to show that continued slipping with extra coke will raise the top heat. With furnaces in extremely bad shape the top heat has been seen at 1,250 deg. and from 80 to 120 extra skips of coke were put in to bring the furnace around. It is needless to say such cases are seldom encountered.

Too Much Ore for Stone

A number of cases have come to notice where a high top heat may be caused by having too much ore on the burden for the amount of stone that is carried. Whether there is or should be any relation between the top heat and the amount of stone carried is a question, yet at times when a high top heat was observed it was noticed that the furnace needed more stone.

Light Charges

The various methods of charging a furnace, the size of the charge and the method of filling are a broad subject in themselves. A feature of particular interest at this time is the fact that a high top heat was repeatedly observed with light charges. It seems that when a heavy charge is used the ore and the stone have a blanket effect of holding down the top heat, while with small light charges the stock becomes intimately or haphazardly mixed and the coke burns up through the charges above.

It is readily seen how a large heavy blanket of ore would tend to lower the top heat. In some instances the charge is four coke, four ore and two stone, while in others it is two coke, two ore and one stone. By the first method there is just twice as much material in each charge as in the second method. Still another instance is known where the charge was made up of but one coke, one ore and one stone. In order to show clearly how charging the furnace affects the top heat and furnace operation a number of examples used on different furnaces will be given.

In No. 1, the full charge is lowered at once, the stock being put on the big bell in the order of coke, ore and stone. In No. 2, four skips of coke are put on the bell and it is then lowered, then four skips of ore and the bell lowered, and then two skips of stone and the bell lowered. In this method each material is dropped into the furnace separately. In No. 3, the big bell is lowered six times to the round, or after two coke, after one stone, after two ore, after two coke, after one stone and after two ore have been put in. In No. 4, the big bell is lowered four times, once after two coke, once after

DIFFERENT METHODS OF CHARGING THE FURNACE

		Lb.	
1.	4 Coke	3,000	Lower big bell once
	4 Ore	5,700	
	2 Stone	3,650	
2.	4 Coke	2,460	Lower big bell three times
	4 Ore	5,100	
	2 Stone	3,030	
3.	2 Coke	2,580	Lower big bell six times
	1 Stone	2,700	
	2 Ore	5,400	
4.	2 Coke	3,060	Lower big bell four times
	2 Stone	3,180	
	2 Coke	3,060	
	4 Ore	5,400	
5.	2 Ore	5,100	Lower big bell twice
	1 Stone	2,880	
	2 Coke	2,940	
6.	2 Coke	5,680	Lower big bell once
	2 Ore	8,000	
	1 Stone	3,000	
7.	2 Coke	5,680	Lower big bell once
	1 Ore	4,000	
	1 Stone	3,000	
8.	1 Coke	2,840	Lower big bell once
	1 Ore	3,500	
	1 Stone	3,300	

two stone, once after two coke and once after four ore. In No. 5, the big bell is lowered only twice, once after two ore, one stone and two coke have been put in and again after two more ore, one stone and two coke have been put in. In No. 6, the big bell is only lowered once, when two coke, two ore and one stone are put in. In No. 7, the big bell is lowered only once after two coke, one ore and one stone have been put in. In No. 8, the big bell is lowered only once, after one coke, one ore and one stone have been put in.

The point to be brought out clearly here is that when the amount of ore and stone is light in proportion to the amount of coke then the top heat is likely to be high, or in other words, when there is a surplus of fuel present.

Letting the Furnace Go Down

Smoothest furnace operation is always obtained when the filling is even and regular. It is of vital importance that the stock is not let go down, for this means starting irregular driving. If the furnace is not charged for long intervals of time, this is immediately shown on the top heat chart. The curve will keep on rising until cold stock is put in, when it will show exactly the time recharging began by the fall in the curve. The furnace should be filled as soon as there is room for a charge to be put in. This assures regular driving and heats the charge long before it gets down in the furnace. In addition it keeps the top heat down.

An example of particular interest which illustrates the value of filling the furnace regularly and keeping it full is shown in the following incident. It was in the winter time when about 6 in. of snow was on the ground. The furnace was tested with the gage rod, which registered full. It was tested again some time later, and the rod again registered full. Although there was no evidence of hanging, still after two hours the rod showed the furnace to be full. At the end of four hours suspicion pointed to the gage rod, and it was found that it would go down just so far and then stick.

The furnace had gone down 30 ft. Filling was kept up all night to get it full again. At 4 o'clock in the morning it started to hang. Then the pressure started to rise. Every effort was made to make it take stock, but the cold stock had come down from above and the furnace went violently cold. At 3:10 in the afternoon the stock came down with a terrific explosion tearing the bottom out of the dust catchers and covering the ground with ore, coke and limestone. It was weeks before it ran smoothly again. This shows the effect of cold stock coming down quickly into the hearth. When the furnace is kept full, the stock is heated gradually all the way down. The top heat chart shows how long the furnace has been let go down, or the interval between filling.

White Smoke From the Stove Stacks

White smoke from the stove stacks is an indication of a hot furnace. The top heat may or may not be high at this time, but such a condition is very often accompanied by a high top heat. For instance, a top heat of 870 deg. was shown on a furnace when extremely heavy white smoke could be seen at the stoves and boilers. As the fumes or smoke decreased in volume the top heat went down to 740, then 620, and then to 580.

Slips

Slips are shown on the top heat chart by an immediate rise in top heat. The stock having dropped down in the furnace, the loosened charge allows the hot gases to come clear to the top of the furnace. Just as soon as filling starts the cold charges going in have the effect of lowering the temperature. This is seen by the falling step-like top heat curve, which shows a step down when each new charge is dropped in.

Slow Driving

It is natural to expect a rise in the top heat when the furnace drives slow and a fall in the top heat when the furnace drives fast. The explanation is simple, so it will not be discussed. A typical example of extremely high top heat is shown on a heavily limed furnace which only took thirty-eight charges during the day. The top heat was around 875 deg. and all during the day there were explosions on top due to the high heat. The stock was heavily watered and as a radical resort even full skips of water were run into the furnace before the top heat was finally brought under control. This is an example of slow driving.

The same furnace, which normally took forty charges to the shift, showed a top heat of 520 deg. on fast driving lean furnace when forty-five charges were put in. At another time a top heat of 500 deg. was registered when forty-six charges were put in. It might be stated the normal top heat of this furnace was 400 to 500 deg.

As stated before, the position of the fusion zone has a decided influence on the top heat. This same furnace showed a top heat of 600 to 670 deg. when forty-eight charges were put in, but the fusion zone was high. One of the quickest ways to raise the fusion zone is by putting a large extra coke blank or by running in cold air over a considerable length of time.

It must be remembered that furnace conditions are very flexible and the examples cited are the general behavior under certain definite operation. For example, a furnace on lake ores was cold on top and hot in the bottom and took only twenty-two charges, which was extremely slow driving. The top heat registered only 350 deg. The filling report shows the furnace to be hanging all day and twenty extra skips of coke were

put in. Thus it is seen that there are exceptions to the rule.

On the other hand, often ideal examples occur. Such an illustration showed that the top heat curve ran all day long and all night evenly recording 400 deg. top heat. The top heat curve was an even saw-toothed curve all the way around, with no large peaks or any irregularities of any kind. The stove heat was 950 deg. all day, the blast pressure ran smoothly all day long at 9.5 lb., and driving was smooth, quiet, even and regular. These conditions were ideal furnace conditions and therefore as the result an ideal top heat curve was recorded.

Other Features and Indications of High Top Heat

The stove changes not only affect the stove charts but often, especially when making a radical change in the stove heat, say from 700 to 1,000 deg., the increase in temperature is also noted with a corresponding small increase in top heat.

During a shut-down to change a tuyere, cooler, water block, etc., there is a rise in temperature of the top heat, which is indicated by the rise on the chart during the shut-down interval. This is easily explained as due to the decrease or entire slowing down of the velocity of the gases. They are not carried off so rapidly and hence are much hotter.

It is interesting to compare the top heat charts of a skip-filled and a hand-filled furnace. The peaks or teeth of the former are regularly larger than the fine, small, band-saw teeth of the hand-filled furnace. A hand-filled furnace is seldom full and the filling is therefore continuous, while with a skip-filled furnace the stack is filled in from twenty to twenty-five minutes and then allowed to drive for about the same interval of time.

Brief mention has previously been made of the influence of extra coke on the top heat. It is naturally to be expected that a rise will be shown in the top heat after a large extra coke blank. A furnace running on lake ores which showed a top heat around 350 deg. showed a top heat of from 650 to 700 deg. after eighty skips of extra coke had been put in. Another instance was seen when the top heat ran around 1,000 deg. when sixty extra coke were put in every day for a week.

The top heat curve falls off to nothing when the furnace is banked. This is gradual and is registered as an even falling curve on the top heat chart.

Pittsburgh, Pa.

Determination of Available Lime in Quicklime and Hydrated Lime

By Alice I. Whitson

FOR most chemical purposes free or uncombined calcium oxide is the valuable constituent of lime, and in practice limes are bought and sold on this basis. Notwithstanding this fact, there is no generally accepted method for obtaining this value, and there has been for some time a demand from various industries for a practical and reliable method.

At the request of the Interdepartmental Conference on Chemical Lime, a series of comparative analyses was made by the Geological Survey, the Bureau of Chemistry and the Bureau of Standards, each using duplicate samples of high-calcium and high-magnesium quick and hydrated limes representing the four types of lime in use. Complete gravimetric analyses were first made for comparison purposes and calcium oxide determinations were then made by the seven methods for the determination of free lime given in detail by R. K. Meade in *Concrete*, vol. 10 (1917), Cement Mill Section, p. 25.

The results obtained by the Scaife method were most promising and further investigation of this method at the Bureau of Standards led to the following modified procedure:

Place 1.4 g. of the carefully prepared and finely ground (passing 100 mesh) lime in a 400-c.c. beaker, add 200 c.c. of hot water, cover, heat carefully and then boil for three minutes.

Cool, wash down cover, add two drops of phenolphthalein and titrate with N hydrochloric acid, adding the acid dropwise as rapidly as possible and stirring vigorously to avoid local excess of acid. When the pink color disappears in streaks, retard the rate of addition of acid somewhat, but continue until the pink color disappears entirely and does not reappear for 1 or 2 seconds. Note the reading and ignore the return of color.

Repeat the experiment, substituting for the 400-c.c. beaker a 1-liter graduated flask carrying a one-hole stopper fitted with a short glass tube drawn out to a point. Cool and add dropwise and with vigorous stirring 5 c.c. less acid than before. Call the number of c.c. used *A*. Grind up any small lumps with a glass rod flattened at one end, dilute to the mark with freshly boiled distilled water, close the flask with a solid stopper, mix thoroughly for 4 or 5 minutes and let settle for half an hour.

Pipette a 200-c.c. portion, add phenolphthalein, and titrate slowly with 0.5 N hydrochloric acid until the solution remains colorless on standing 1 minute. Call this additional number of c.c. *B*. Then the percentage of available CaO $= 2A + 5B$.

Table I presents determinations which were made by the modified method.

TABLE I. DETERMINATIONS OF AVAILABLE LIME BY MODIFIED SCAIFE METHOD

Sample	Uncombined CaO Present (Calculated From Complete Analysis)	Available Lime Found Operator A	Operator B
Calcium quicklime	93.4	93.4	93.4
		93.5	93.3
Calcium hydrate	87.3	85.0	85.0
		85.0	84.3
High-magnesium quicklime	58.0	57.9	58.0
		58.0	58.1
High-magnesium hydrate	50.0	50.3	50.0
		50.0	50.1
MgO and CaO, (0.7 g. each)	49.0	49.3	....
		48.8	....
CaO (precipitated)		100.0	....

All figures are based on the lime ignited at red heat, as prescribed in A.S.T.M. specifications for hydrated lime[1], and the hydrochloric acid was standardized by means of Bureau of Standards benzoic acid No. 48-a, through a sodium hydroxide solution.

It is apparent that the determinations on duplicate samples by the modified method agree within reasonable limits and closely approximate the calculated values. The modified Scaife method is approved by the Interdepartmental Conference on Chemical Lime, and is now being tested in Government and works laboratories.

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[1] *Proc.* A.S.T.M., 1920, p. 629.

Elements of the Superconcentration of Nitric Acid

Application of Distillation Studies of HNO_3:H_2SO_4:H_2O Mixtures to the Economical Production of Highly Concentrated Nitric Acid From Weak Acid — Preconcentration by Distillation Should Precede Superconcentration With Sulphuric Acid—Effect of Hydrochloric Acid and Nitrogen Tetroxide

BY ERNST GALLE

IF WE follow the history of the technology of nitric acid, we can differentiate two great periods. In the first, nitric acid was manufactured from Chilean saltpeter; in the second, from atmospheric nitrogen by means of the electric arc or from ammonia. Both periods have this in common, that the acid is not obtained in concentrated form and must first be concentrated or superconcentrated.[1] It is easy to appreciate, therefore, that from early times the study of nitric acid-water mixtures has attracted the interest of the chemist, resulting in the publication of a series of articles whose findings will be briefly summarized in the following.

PROPERTIES OF AQUEOUS NITRIC ACID SOLUTIONS

Dalton found (*Ann. Phil.*, vol. 9, p. 186, vol. 10, pp. 38 and 83) that in the distillation of an acid whose density is less than 1.40 at first a weaker acid comes over, until the constant distilling residue has a density of 1.42; this residue boils at 120 deg. C. According to Mitscherlich it boils at 120 to 121 deg. C.; according to Millon at 125 to 128 deg. C.; according to Smith at 121 deg. C. At ordinary atmospheric pressure, after sufficiently long boiling of nitric acid of any concentration between 70 per cent and 65 per cent, there is finally obtained a residue of constant composition containing 68 per cent HNO_3, whose boiling point at 735 mm. mercury is 120.5 deg. and whose density is 1.414. If the distillation is carried out at 70 mm. pressure the residue contains 66.7 per cent HNO_3 and boils under this pressure at 65 to 70 deg. C. At 150 mm. the HNO_3 content is 67.6 per cent, at 1,220 mm. 68.6 per cent—i.e., 0.6 per cent higher than at ordinary pressure.

If, by the passage of dry air, one-third, one-half or three-fourths of the acid is evaporated, the residue shows a composition dependent upon the temperature but independent of the composition of the acid used, and contains at 13 deg. C. 64 per cent, at 60 deg. C. 64.5 per cent, at 100 deg. C. 66.2 per cent HNO_3 (Roscoe, *Ann. Phil.*, 203, 1860).

The peculiar discontinuity of the properties of aqueous nitric acid solutions led to the assumption of the presence of various hydrates, which were first reduced by Küster & Koomann[2] [*Z. anorg. Chem.*, vol. 41, p. 1 (1905)] to $HNO_3.3H_2O$ and $HNO_3.H_2O$ and isolated by Pickering [*J. Chem. Soc.*, vol. 63, p. 436 (1893)]. More complete summaries, which will not be taken up as beyond the scope of this article, are found in Abegg, "Handbuch der anorganischen Chemie," vol. III, part 3, p. 158, and Spiegel, "Der Stickstoff und siene wichtigsten Verbindungen," p. 204.

If the two curves in Fig. 1 are examined, of which the first gives the boiling points of nitric acid solutions of various concentrations and the second the boiling points of sulphuric acid solutions of various concentrations, it can readily be seen that aqueous nitric acid can be separated by simple distillation only to an acid of 68 per cent strength, while aqueous sulphuric acid yields an acid of 98.3 per cent strength. Consequently, in order to obtain a highly concentrated nitric acid, two separate phases must be considered: a concentration to 68 per cent and a superconcentration to 98 per cent, which latter must principally be carried out with other means than is the case with sulphuric acid. Experiments by Guido Pauling give the results shown in Fig. 2, when distilling acid below 68 per cent strength.

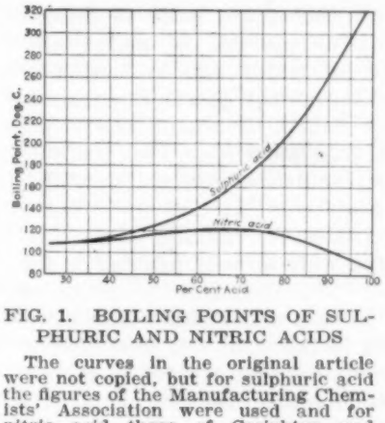

FIG. 1. BOILING POINTS OF SULPHURIC AND NITRIC ACIDS

The curves in the original article were not copied, but for sulphuric acid the figures of the Manufacturing Chemists' Association were used and for nitric acid those of Creighton and Githens.

Concerning the distillation of acids stronger than 68 per cent, experiments have yielded the following:

Nitric acid having a density of 1.503, freed from N_2O_4 by blowing warm air through it, showed boiling points rising from +88 deg. to +121 deg. C., leaving behind at the latter temperature a residue containing 77.1 per cent HNO_3. The portion boiling between 88 deg. and 93 deg. is strongly colored red; when bleached, this acid has a density of 1.516 and a boiling point of 84.4 to 86.7 deg.; when redistilled it yields an acid of 1.517 density with a boiling point of 84.4 deg. C. (Smith, *Pharm. Centralbl.*, vol. 19, p. 203).

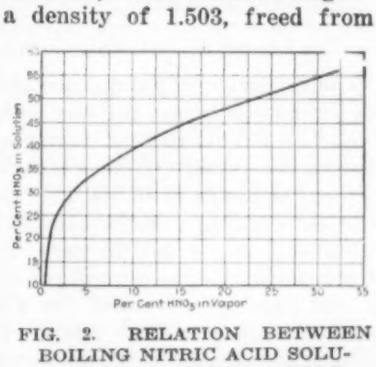

FIG. 2. RELATION BETWEEN BOILING NITRIC ACID SOLUTIONS AND THEIR VAPORS

Acid of a density of 1.55 when distilled first yields an acid of 1.62 density (containing N_2O_4), then of 1.53; the residue shows a density of 1.49 (Proust). More lately Creighton and Githens [*J. Franklin Inst.*, vol. 179, p. 161; abstr. in *Z. angew. Chem.*, vol. 2, p. 208

Translated from *Z. angew. Chem.*, 1921, vol. 34, pp. 168-170, 173-175, by F. C. Zeisberg, Chemical Department, E. I. du Pont de Nemours & Co.

[1] There is no English equivalent of the German "Hochkonzentration," used both as noun and verb. The word "superconcentration" has hence been coined, to be applied when the resulting product, particularly nitric acid, is concentrated to a high degree (above 90 per cent in the case of nitric acid). F.C.Z.

[2] Undoubtedly an error for "Kremann." F.C.Z.

(1916)] have determined the boiling points and vapor pressures of aqueous nitric acid solutions by the dynamic method. From the locations of the maxima of the boiling point curves the variation of the composition of the mixtures of maximum boiling point with the pressure is established.

Interesting results were also obtained by Konrad Schaefer [*Z. angew. Chem.*, vol. 2, p. 56 (1916)] from the absorption spectra of gaseous nitric acid. The NO_3 group exists in two constitutionally different modifications: a selective absorbing form in inorganic nitrates and dilute aqueous nitric acid, and an end absorbing form in alkyl nitrates, in concentrated nitric acid solutions and also in gaseous nitric acid.

Development of Nitric Acid Technology

Let us now examine the period during which nitric acid was made from Chilean saltpeter and sulphuric acid. In his "Handbook of Sulphuric Acid Manufacture" Lunge pictures the development of this industry from its first beginning up to the present. From the statements therein we see the efforts made to recover as high a concentration as possible of nitric acid, through changes in the apparatus and by means of various devices. By means of the processes of Guttmann and the Chemische Fabrik Griesheim (Ger. Pat. 59,099), Uebel's three retort system (Ger. Pat. 106,962) and Valentiner's vacuum distillation process (Ger. Pat. 63,207) this aim was achieved.

By this time the processes for making nitric acid from atmospheric nitrogen were already figuring in the technique. In their book "The Technical Utilization of Atmospheric Nitrogen" Donath and Frenzel give a collected review of the work in this field. "The Oxidation of Ammonia to Nitric Acid" has been treated by Donath and Indra in a monograph whose basic contents have been included by Lunge in the fourth edition of his handbook of the sulphuric acid industry. From all these processes only weak nitric acid results, which in the best cases contains 50 per cent HNO_3. If this is not directly worked up into ammonium, potassium, sodium or barium nitrate, but is destined for the explosives industry, then a further concentration is unconditionally necessary.

The Improved Pauling Concentration Process

The process of Pauling, already used successfully on the large scale before the war, has, after many improvements by Dr. A. Hoenig, which among others included raising the capacity from a steam consumption of 1,500 kg. per 24 hours to 19,000 kg., proved very good. The original Pauling process showed a great many disadvantages. Above all, in case of stoppage from mud, it was impossible to remove the Steuler filling material. It was necessary to wash for a long time with water to set the tower in order again. In washing, acid losses naturally occur, while on the other hand both the lining and the packing are likely to crack from local overheating. In order to avoid these disadvantages the manhole 1, as shown in Fig. 3, was devised by Dr. Hoenig.

The Steuler packing, of the size of a man's fist, necessitated a low rate of acid feed and a correspondingly low steam consumption. By filling the tower with Raschig rings the water evaporating capacity was increased twelvefold. Moreover, stoppages from mud were observed much more infrequently. The rings, also, have proved very resistant; after 1,000 hours' operation the decrease in weight was hardly worth mentioning (0.21 per cent).

The final form of Dr. Hoenig's improved Pauling tower is best described by means of the diagrammatic sketch in Fig. 3. This consists of a column *A*, of about 8 m. height, of cast-iron sections. The lower section (base section *a*) carried the manhole 1, the steam jet *F*, and the exit pipe 2, for the denitrated, dilute sulphuric acid. Between the bottom section *a* and the second section *b* a silicon iron grating *G* is inserted, which carries the packing (Raschig rings). The top section *g* is not packed. It contains the acid distributor *H*, and carries the gas exit pipe 3, which leads to the condenser, the three inlet pipes for dilute nitric acid 4, concentrated sulphuric acid 5 and waste acid 6, as well as a thermometer 7. The column is lined with acid-resisting masonry.

The condenser *B* is a silicon iron coil cooled by a water spray. The 49 deg. acid condensing here runs off through the pipe 8 to earthenware pots, from which the acid can be filled into traveling pots or carboys. In addition, the condenser is connected, through pipe 9, with a stoneware exhauster, which blows the gases uncondensed in *B* into absorption towers, in which the last portions of nitrous oxides are absorbed. The weak acid resulting therefrom is returned to the process. The weak denitrated acid running off at a strength of 57 deg. Bé. enters the cooler *D* and from here goes to the sulphuric acid concentrating plant.

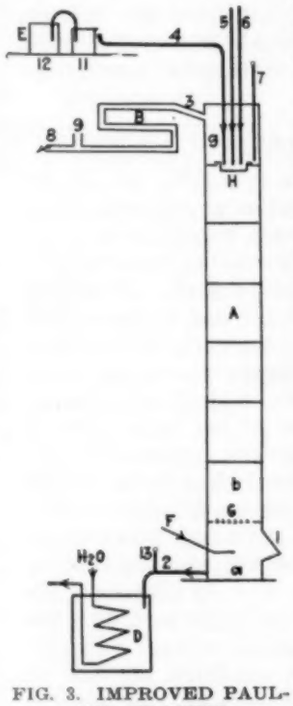

FIG. 3. IMPROVED PAULING PROCESS

At *E* is the acid distribution. From reservoirs set higher the dilute nitric acid flows through the glass vessels 11 and 12; the concentrated sulphuric acid and the waste acid flow to the tower. The amount of acid added can be roughly regulated by varying the cross-section of the siphon, the finer regulation being obtained by using the adjustable level 11. For handling all the acid, silicon iron pumps (Patscher construction) and pumps of acid-proof castings with chromium steel shafts made by Eichter in Wesseling have proved excellent. Before operating, the tower must first be heated to a certain high temperature. To do this, concentrated 66 deg. sulphuric acid is allowed to run slowly into the tower through pipe 5 for about 48 hours. At the same time, steam is admitted carefully through *F* with a pressure of two atmospheres. Both the acid and the steam are gradually increased until after 48 hours the thermometer 7 reads 130 deg. Then, through 4, dilute 30 deg. Bé. nitric acid is allowed to run in and the sulphuric acid and the steam are so regulated that a nitric acid of 49 deg. flows off through 8 and the residual sulphuric acid is free from nitric acid. With normal operation the thermometer 7 stands at about 112 deg. C., thermometer 13 at about 167 deg. C., and the residual sulphuric acid has a strength of about 57 deg. Bé. (73 per cent H_2SO_4).

According to Pauling's original statements 5 parts of concentrated sulphuric acid should be used to concentrate 1 part of nitric acid. As an experiment, waste acid (75 per cent H_2SO_4, 12 per cent HNO_3, 13 per cent H_2O) was allowed to flow in through 6; it developed that the tower would completely denitrate this acid, and in addition that concentrated sulphuric acid equivalent to the sulphuric acid content of the waste acid could be saved. The partial reduction of nitric acid to nitrous acid brought about by the nitro-body content of the waste acid was neutralized by increasing the size of the condenser. Let us now examine in the following table of operating results, and the data calculated therefrom, the nitric acid-sulphuric acid ratios on the one hand and the water-sulphuric acid ratios on the other, obtained with the tower operating full capacity (10,000 kg. 99 per cent HNO_3 in 24 hours) and with different strengths of weak nitric acid fed to the tower.

The operation of the tower for 24 hours then gives:

	H_2SO_4, kg.	HNO_3, kg.	H_2O, kg
H_2SO_4 (66 deg.)	43,000	.....	6,970
HNO_3 (33 deg.)	.....	11,280	13,620
Steam	.....	.....	1,390
	43,000	11,280	21,980

Sulphuric Acid Consumption Increased With Dilute Nitric Acid

If waste acid is added, the addition of concentrated sulphuric acid is reduced correspondingly, without, however, causing any change in the remaining ratios. Much more sulphuric acid is, however, necessary with dilute nitric acid. Care must hence be taken, by adding various stronger acids, not to allow the concentration to drop below 30 deg. On the contrary, if the acid is stronger, then not only is the production of highly concentrated acid in unit time greater but the sulphuric acid consumption drops appreciably. (See Table I.)

Now, there was not only pure atmospheric nitric acid available for superconcentration, but also various dilute nitric acids containing hydrochloric acid. With these latter the sulphuric acid consumption increases considerably, as compared with the consumption for pure acids of like concentration; the explanation for this is given in experiments to be described later. Above, the corresponding figures obtained in actual operation are given.

TABLE I. OPERATING RESULTS WITH DIFFERENT STRENGTHS OF WEAK NITRIC ACID

Strength of Weak Nitric Deg. Bé.	Per Cent	$HNO_3 : H_2SO_4$	$H_2O : H_2SO_4$	Remarks
27	36.5	0.143	0.253	
30	41.3	0.196	0.323	
31	43.0	0.204	0.455	
32	44.7	0.250	0.475	
33	46.5	0.263	0.500	
30	....	0.143	0.250	Weak acid with 2 per cent HCl

Behavior of Nitric Acid-Sulphuric Acid Mixtures

Experience shows, therefore, that in superconcentrating very dilute acids or acids containing hydrochloric acid the sulphuric acid consumption increases, with an appreciable decrease in the production. The following experiments were hence carried out to study the causes of this phenomenon, in order, so far as possible, to avoid them. Very few references are available in the literature with respect to the behavior of nitric acid-sulphuric acid mixtures. The only known work is the study of A. Saposchnikow, appearing in the *J. Russ. Phys. Chem. Soc.*, and mentioned in the *Chem. Zentralbl.* (1904, p. 395; 1905, pp. 381, 1152)[3]. Saposchnikow investigated the partial pressure of nitric acid mixed with increasing amounts of sulphuric acid, the composition of the vapor carried out of these mixtures by the air stream at 25 deg. C., the vapor density of these mixtures and their electrical conductivity. The picture of the reaction, given in the form of curves, is veiled by the nitrogen oxide content of the nitric acid used. Further, he found the vapor pressure of an acid of 1.478 sp.gr. to be much lower than that of an acid of 1.52 sp.gr.—viz., 16.64 mm. By the addition of H_2SO_4 it increases noticeably, reaching a maximum in mixtures with 35 per cent H_2SO_4. Numerous systematic experiments on the nitrating action of nitric acid-sulphuric acid mixtures on cellulose are mentioned. Besides, he concludes from his experiments on the vapor pressures at 25 deg. C. that the water contained in concentrated nitric acid (42 deg. Bé.) is completely removed by the sulphuric acid, which circumstance explains the applicability of such mixtures to the manufacture of nitrocellulose. From the partial pressure curves it is to be seen that very small amounts of water reduce the partial pressure of nitric acid very considerably, which explains why even the strongest nitric acid, without sulphuric acid, is not suitable for the manufacture of nitrocellulose. In further experiments he studied the nitrating action of sulphuric acid mixtures with dilute nitric acid and found that the water-abstracting sulphuric acid increased the number of free molecules of nitric acid.

More lately Creighton and Githens (*J. Frank. Inst.*, vol. 180, p. 703) investigated the influence of sulphuric acid on aqueous nitric acid at atmospheric and reduced pressures, and found that at 760 mm. nitric acid of maximum boiling point contains 68.18 per cent HNO_3 without sulphuric acid, 64.5 per cent in the presence of 10 per cent H_2SO_4 and 59.2 per cent in the presence of 20 per cent H_2SO_4.

Konrad Schaefer (*Z. angew. Chem.*, 1917, p. 56) made optical experiments in this domain and found that dehydration of nitric acid results in a constitutional change in the NO_3 group. Very likely those nitric acid molecules which contain the end absorbing form of NO_3 group largely, or perhaps wholly, react during nitration. These, to my knowledge, are the only researches in this field.

Distillation Phenomena With Weak Nitric Acid

In the following are given the experiments carried out by the author on the superconcentration of nitric acid and their results. As raw material for the following first series of experiments a nitric acid of 25 deg. Bé. was used, obtained by the oxidation of ammonia by the Ostwald process. Analysis showed: Sp.gr. 1.210, HNO_3 33.48 per cent, HNO_2 0.14 per cent.

Of this acid 500 c.c. (corresponding to 167.4 g. monohydrate) was distilled in a distilling flask fitted with a Liebig condenser. Between 102 and 106 deg. 256 c.c. passed over; in the flask 244 c.c. remained. The distillate tested 2.1 deg. Bé. and analyzed, sp.gr. 1.015, HNO_3 2.90 per cent, HNO_2 0.29 per cent. The residue tested 41.2 deg. Bé. and analyzed, sp.gr. 1.400, HNO_3 65.56 per cent, HNO_2 0.00 per cent.

[3]Galle is evidently unfamiliar with the work of Pascal. See Pascal, *Compt. rend.*, vol. 165, pp. 589-91 (1917), and C. de la Condamine, *Ind. Chim.*, No. 54, pp. 153-5, 187-9 (1918), for partial pressures of mixed acid solutions at boiling temperatures, and their boiling points; Pascal and Garnier, *Bull. Soc. Chim.*, vol. 27, p. 18 (1920) for specific heats of mixed acid solutions and *Bull. Soc. Chim.*, vol. 25, p. 145 (1919), for sp.gr. of mixed acid solutions at various temperatures.

In order to study the relations more closely another 500 c.c. was distilled and the distillate was caught in 25 c.c. lots and titrated with N/2 NaOH and methyl orange. From a series of experiments, which agreed well among themselves, the average figures shown in Table II were obtained.

Besides, it was observed that already at 90 deg. vapors of NO_2 appeared which dissolved partially, with the development of a blue color, in the first portions of the distillate and partially escaped into the air. A peculiar smell was also observed, reminiscent of ozone,

TABLE II. DISTILLATION OF 500 C.C., 25 DEG. BÉ. NITRIC ACID

No.	C.C.	C.C. N/2 NaOH	Per Cent HNO_3	Per Cent HNO_2	Boiling Point Deg. C.
1	25	26.40	1.36	1.46	102
2	25	11.40	1.44	....	103
3	25	12.30	1.55	....	104
4	25	13.90	1.75	....	104
5	25	16.40	2.07	....	105
6	25	19.50	2.46	....	105
7	25	24.60	3.10	....	106
8	25	26.20	3.30	....	106
9	25	38.50	4.85	....	106
10	25	50.00	6.30	....	106
Total distillate, 250		239.20	2.82	0.15	104.7

The residue tested 40.8 deg. Bé. and analyzed, 1.395 sp.gr., 64.22 per cent HNO_3, 0.00 per cent HNO_2.

but which could not be chemically proved to be this substance. Graphically expressed, the strength of the resulting acid is given in Fig. 4.

Preconcentration of Weak Nitric Acid

Next, an attempt was made to see whether it was possible to obtain a distillate wholly free from HNO_2, in order to investigate the possibility of preconcentrating the weak acid commercially and thus to avoid the irksome necessity of returning the dilute 3 per cent distillate to the nitric acid absorption towers of the ammonia oxidation plant. After many experiments an apparatus of the following design (see Fig. 5) was finally constructed by a glass blower, and insulated with asbestos paper. The flask *A* had a volume of about 1 liter; the column *B*, filled with glass beads, was 40 cm. long and 4 cm. in diameter, and contained at the top a thermometer well *b*, which was fused in. In order to facilitate charging with weak acid, the opening *C* was provided.

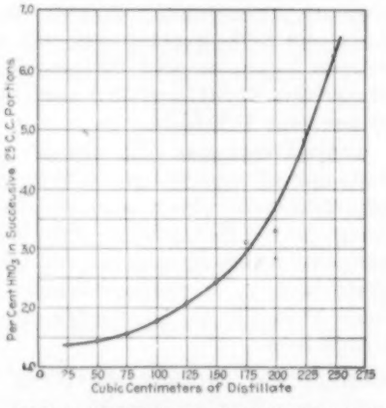

FIG. 4. STRENGTH OF DISTILLATE WHEN DISTILLING 500 C.C. 33.5 PER CENT HNO_3

TABLE III. PRECONCENTRATION OF WEAK NITRIC ACID

No.	C.C.	C.C. N/2 NaOH	Per Cent HNO_3	Per Cent N_2O_4	Boiling Point, Deg. C.
1	25	2.30	0.04	0.18	99
2	25	0.35	0.04	....	99
3	25	0.55	0.07	....	99
4	25	0.40	0.05	....	99
5	25	0.35	0.04	....	99
6	25	0.30	0.04	....	99
7	25	0.25	0.03	....	98.5
8	25	0.25	0.03	....	98.0
9	25	0.30	0.04	....	99.0
10	25	0.50	0.06	....	113.0
Total distillate, 250		5.55	0.044	0.018	100.25
11	25	129.00	16.24	....	117
12	25	140.00	17.60	....	118

Again, 500 c.c. of dilute nitric acid was subjected to distillation. The thermometer rose to 99 deg. C. and 225 c.c. distillate passed over. Then the distillation began to lag. By adding a second burner it became more lively, but the temperature also rose. Table III again gives the average of a series of distillations.

The residue of 250 c.c. showed a sp.gr. of 1.40 and contained 64.14 per cent HNO_3. From these experiments it is clearly evident that it is possible with suitable apparatus to preconcentrate nitric acid to about 65 per cent without the addition of a water-binding material; a further concentration is, of course, out of the question.

Superconcentration of Preconcentrated Acid

Experiments were then made to superconcentrate the acid of 41 to 42 deg. Bé. thus obtained, by the addition of sulphuric acid. An acid of sp.gr. 1.410, containing 67.10 per cent HNO_3 and 0.02 N_2O_4, served as a starting point. This was mixed in the distilling flask with sulphuric acid of 66 deg. and distilled. From a series of experiments in which 25 c.c. portions of the distillate were again collected, the results shown in Table IV were obtained.

TABLE IV. DISTILLATION OF HNO_3 (1.410) + H_2SO_4 (1.84)

$HNO_3 : H_2SO_4$	$H_2O : H_2SO_4$	Boiling Point, Deg. C.	Per Cent HNO_3 in Dist.
5.00	2.40	118.8	74.66
2.42	1.20	117.6	79.72
1.61	0.81	113.8	84.55
1.18	0.59	110.0	90.75
1.00	0.50	101.2	96.80
0.67	0.33	95.8	96.69
0.50	0.25	93.0	96.72
0.40	0.20	88.6	96.74

From this it is evident that it is possible, by the addition of concentrated sulphuric acid, to obtain highly concentrated nitric acid from an acid of 1.41 sp.gr. An acid of 96.8 per cent HNO_3 (on the large scale, continuously, 99 per cent HNO_3) is obtained in the laboratory even when the water:sulphuric acid ratio is 0.5—i.e., when the water contained in the 1.41 acid has the ratio 1 : 2 to the sulphuric acid monohydrate. A further addition of sulphuric acid, it is true, raises the vapor pressure of the nitric acid-sulphuric acid-water mixture, and as a result thereof lowers the boiling point, but this is without significance in the industrial process. If hydrochloric acid is added to the nitric acid (2 per cent of the monohydrate content), a raising of the boiling point to 113 deg. C. resulted with the $H_2O : H_2SO_4 = 1:2$ ratio, and an acid of 90.18 per cent HNO_3 distilled over, which, however, contained 0.41 per cent NOCl. This result corroborates the operating fact that a larger amount of sulphuric acid is necessary to superconcentrate nitric acid which contains hydrochloric acid. The hydrochloric acid content raises the boiling point, the vapor pressure is lowered as a result of the

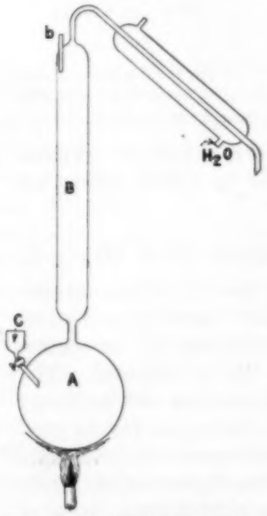

FIG. 5. PRECONCENTRATION APPARATUS

formation of nitrosyl chloride, and this latter must be broken down by an excess of sulphuric acid in order to make possible a normal operation.

Superconcentration Without Preconcentration

Next, experiments were carried out to learn how the dilute acid direct from the oxidation process, without any preconcentration, behaved when subjected direct to superconcentration with sulphuric acid. First, an acid obtained from the oxidation of ammonia (by the Ostwald process) and having a sp.gr. of 1.21 (33.48 per cent HNO_3) was mixed with sulphuric acid and distilled. The averages of a series of runs are shown in Table V.

TABLE V. DISTILLATION OF HNO_3 (1.21) + H_2SO_4 (1.84)

$HNO_3 : H_2SO_4$	$H_2O : H_2SO_4$	Boiling Point, Deg. C.	Per Cent HNO_3 in Dist.
1.00	2.00	110	18.80
0.25	0.5	117.6	65.00
0.17	0.33	118.3	80.69
0.13	0.25	115	89.76
0.10	0.20	110	99.11
0.08	0.16	109	93.38

Next, an arc process acid (Pauling system) of 1.295 sp.gr. (46.65 per cent HNO_3) was treated in the same way. In Table VI the average figures from a series of experiments are given.

TABLE VI. DISTILLATION OF HNO_3 (1.295) + H_2SO_4 (1.84)

$HNO_3 : H_2SO_4$	$H_2O : H_2SO_4$	Boiling Point, Deg. C.	Per Cent HNO_3 in Dist.
1.72	2.0	116	42.95
0.87	1.0	118.3	69.36
0.50	0.5	116.3	80.07
0.20	0.33	110.6	92.44
0.25	0.25	109.0	95.54
0.18	0.20	103.3	96.45

If the figures given in Tables IV, V and VI are now plotted on co-ordinate paper, the results shown in Fig. 6 are obtained. The abscissas represent the H_2O:H_2SO_4 ratio and the ordinates of the upper set of curves boiling points. The ordinates of the lower set of curves represent strength of distillate.

Direct Superconcentration of Weak Acid Uneconomical

From these diagrams it is evident that the more concentrated the nitric acid is which is to be distilled the less sulphuric acid is necessary to superconcentrate it. With increased addition of sulphuric acid the vapor pressure is raised and the boiling point approaches that of pure nitric acid. With the decrease in boiling point the concentration of the distillate simultaneously increases. The use of nitric acid containing hydrochloric acid is, so far as possible, to be avoided in the concentrating operation.

On the manufacturing scale it is hence evident that the use of an acid weaker than 40 deg. Bé. is without question to be avoided. Care must be taken to preconcentrate to 40 deg. and then first to employ the resulting acid for superconcentration. An example will be given: If acid of 30 deg. is subjected to superconcentration, then roughly five times the weight of the nitric acid monohydrate of sulphuric acid will be necessary—viz., in 24 hours 10,000 kg. of HNO_3 (99 per cent) requires 50,000 kg. of H_2SO_4 (66 deg.). If this 30 deg. acid is replaced, through preconcentration, with acid of 40 to 42 deg. Bé., then for the same daily production of nitric acid 20,000 kg. of sulphuric acid suffices, 40 per cent of that necessary in the first case. No cognizance has been taken of the fact, either, that as a result of the discharge of stronger acids the capacity of the tower is appreciably increased in the second case. Since in practice, however, the capacity of a concentrating plant is usually dependent upon that of the sulphuric acid concentrating apparatus, it is self-evident that, presupposing the necessary spares for superconcentration, the output of a superconcentration plant can be about trebled by preconcentration.

Avoiding Losses Due to Nitrogen Tetroxide

Since it is often the case that weak nitric acid from denitrating operations is sent to the superconcentrating plant, or, to save sulphuric acid, so-called waste acids are run into the concentrating tower, the behavior of the nitrogen tetroxide contained in these acids was investigated. First, a waste acid from a nitrocotton factory, of the following composition, was distilled: Sp.gr. 1.710, H_2SO_4 70.00 per cent, HNO_3 6.74 per cent, N_2O_4 2.86 per cent, H_2O 20.40 per cent; color yellow green. There first condensed a yellow green liquid, which later became underlain with a brown colored layer; some uncondensed nitrogen tetroxide escaped. Because of the great volatility of the condensed substances (on sucking them into a pipette they vaporized), these could be regarded as nitrous acid (Fritsche, *J. prakt. Chem.*, vol. 19, p. 179) and nitrogen tetroxide (Dulong, *Ann. chem. phys.*, vol. 2, p. 317).

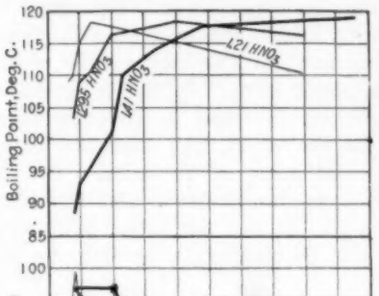

FIG. 6. EFFECT OF H_2O : H_2SO_4 RATIO ON CONCENTRATION OF NITRIC ACID

When the distillate was absorbed in potassium hydroxide solution, crystals of potassium nitrate separated in the course of the distillation, while the mother liquor contained potassium nitrite. If nitric acid of high N_2O_4 content is mixed with sulphuric acid and distilled, then only 50 per cent of the N_2O_4 given off is found in the distillate as such. The other half has been oxidized to nitric acid. On this basis half the N_2O_4 contained in highly concentrated nitric acid may be reckoned as nitric acid, since in nitrations it reacts as nitric acid.

In working up nitric acids rich in N_2O_4 it is well, therefore, also to provide an alkaline absorption following the water absorption, to avoid nitric acid losses; the nitrite solution obtained is worked up into nitrate.

Summary

Summarizing this work, the following rules for the superconcentration of nitric acid are indicated:

1. The weak nitric acid must be preconcentrated, without the addition of sulphuric acid, to 42 deg. Bé.
2. The 42 deg. nitric acid is superconcentrated with sulphuric acid, using twice as much sulphuric acid as the water contained in the nitric acid.
3. If the dilute nitric acid contains HCl, then the

H_2SO_4 necessary for superconcentration is increased, with 42 deg. Bé. acid as well as with weaker ones.

4. The N_2O_4 contained in the weak nitric acid is converted into nitric acid to the extent of 50 per cent, in the superconcentration of nitric acids containing it. Equally, 50 per cent of the nitrogen tetroxide in highly concentrated nitric acid reacts as nitric acid in the mixed acid made therefrom.

Progressive and Compartment Dry Kilns for Timber Compared*

The dry kiln becomes yearly of increasing importance to technically-controlled processes, and the findings in each particular instance of operation are valuable for application to conditions in other lines. This may be true of recent work with kilns used in drying lumber.

All lumber dry kilns now on the market are either progressive or compartment kilns. In the progressive type the drying conditions increase in severity from one end of the kiln to the other, the material being moved into severer conditions as it dries. In the compartment type the same temperature and humidity prevail throughout the kiln at any one time, beginning with mild conditions and increasing in severity as the material becomes dry.

The progressive type of kiln requires less skill in the operator. It consumes less heat per pound of water evaporated from the wood, but the saving of steam possible should not be considered so important as the question of ability to perform the work required with the best results. The progressive kiln reaches its greatest heat efficiency in drying from the green state and is most useful in circumstances which permit of its being supplied continuously with green lumber of one thickness and class. It is, however, impracticable with this type of kiln to give individual attention to special loads of lumber.

The compartment type of kiln is more flexible and affords greater control over the drying conditions, permitting less change in temperature, humidity and circulation in the kiln with variations in the wind and weather. It is better adapted to meet the varying requirements of different kinds of material and is most useful where exact and careful drying is required.

*From U. S. Forest Products Laboratory *Technical Notes.*

A Convenient Humidity Table for the Wet and Dry Bulb Thermometer

Users of wet and dry bulb thermometers will find the following table, compiled at the Forest Products Laboratory, Madison, Wis., very useful for quickly determining relative humidity values from wet and dry bulb thermometer readings. To use the table, read the temperatures and subtract the wet bulb readings from the dry. Locate the vertical column of figures headed by the appropriate difference between wet and dry bulb readings, and the horizontal row of figures beginning at the extreme left with the observed dry bulb reading. The figure marking the intersection of these rows is the relative humidity value expressed in per cent.

Take the following as an example: wet bulb temperature, 132 deg. F.; dry bulb temperature, 140 deg.; difference, 8 deg. The figure marking the intersection of the vertical column for 8 deg. difference with the horizontal row beginning with 140 at the extreme left is 79, which is the correct relative humidity for the given thermometer readings.

RELATIVE HUMIDITY TABLE

Difference Between Wet and Dry Bulb Thermometers—in Degrees Fahrenheit

Temperature of Dry Bulb.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
60	94	89	83	78	73	68	63	58	53	48	44	39	34	30																										
70	93	90	85	81	76	72	68	64	59	56	51	47	43	40	37	33	29																							
80	93	91	87	83	79	75	71	68	64	61	57	54	50	47	44	41	38	35	32	29																				
90	96	92	88	85	81	77	74	71	67	65	61	58	55	52	49	47	44	41	39	36	34	31	29	26	25															
100	96	93	89	86	83	79	76	73	70	68	64	62	59	57	54	51	48	46	44	42	39	37	35	33	31	29	27													
102	96	93	89	86	83	80	77	74	71	69	65	62	59	57	54	52	49	47	45	43	40	38	36	34	32	30	28													
104	96	93	90	86	83	80	77	74	71	69	65	63	60	58	55	52	50	48	46	43	41	39	37	35	33	31	29	27												
106	96	93	90	87	83	80	77	74	72	69	66	63	60	58	56	53	51	48	46	44	42	40	38	36	34	32	30	28												
108	96	93	90	87	84	81	78	75	72	70	66	64	61	59	56	54	51	49	47	45	43	41	39	37	35	33	31	29	28											
110	96	93	90	87	84	81	78	75	72	70	67	64	62	60	57	55	52	50	48	46	44	41	39	37	36	34	32	30	28	27										
112	96	93	90	87	84	81	78	75	73	70	67	65	62	60	57	55	53	51	49	47	44	42	40	38	37	35	33	31	29	28										
114	97	93	90	87	84	81	78	75	73	71	68	65	63	61	58	56	53	51	49	47	45	43	41	39	37	35	34	32	30	28	27									
116	97	93	90	88	84	82	79	76	74	71	68	66	63	61	59	56	54	52	50	48	46	44	42	40	38	36	34	33	31	29	28									
118	97	93	91	88	85	82	79	76	74	71	68	66	64	62	59	57	54	53	51	49	46	44	42	41	39	37	35	34	32	30	29	27								
120	97	94	91	88	85	82	79	77	74	72	69	66	64	62	60	57	55	53	51	49	47	45	43	41	40	38	36	34	33	31	30	28	27							
122	97	94	91	88	85	82	79	77	75	72	69	67	65	63	60	58	56	54	52	50	48	46	44	42	40	38	37	35	33	32	30	29	27							
124	97	94	91	88	85	83	80	77	75	72	70	67	65	63	61	58	56	54	52	51	48	46	44	43	41	39	37	36	34	33	31	29	28	27						
126	97	94	91	88	86	83	80	78	75	73	70	68	65	64	61	59	57	55	53	51	49	47	45	43	42	40	38	37	35	33	32	30	29	28						
128	97	94	91	89	86	83	80	78	76	73	71	68	66	64	61	59	57	55	53	52	49	47	46	44	42	40	39	37	36	34	33	31	30	28	27					
130	97	94	91	89	86	83	80	78	76	73	71	68	66	64	62	60	58	56	54	52	50	48	46	44	43	41	40	38	36	35	33	32	30	29	28					
132	97	94	92	89	86	83	81	78	76	74	71	69	67	65	62	60	58	56	54	53	50	49	47	45	43	42	40	39	37	35	34	32	31	30	29	27				
134	97	94	92	89	86	84	81	79	76	74	71	69	67	65	63	61	59	57	55	53	51	49	47	46	44	42	41	39	38	36	35	33	31	31	29	28				
136	97	94	92	89	86	84	81	79	77	74	72	69	67	65	63	61	59	57	55	53	51	50	48	46	45	43	41	40	38	37	35	34	32	31	30	28	27			
138	97	94	92	89	86	84	81	79	77	74	72	70	68	66	63	62	60	58	56	54	52	50	48	47	45	43	42	40	39	37	36	35	33	32	31	29	28	27		
140	97	94	92	89	87	84	81	79	77	75	72	70	68	66	64	62	60	58	56	54	52	51	49	47	46	44	42	41	39	38	36	35	34	33	31	30	28	27		
142	97	94	92	89	87	84	82	80	77	75	73	70	68	66	64	62	60	58	57	55	53	51	49	48	46	44	43	42	40	39	37	36	34	33	32	30	29	28	27	
144	97	95	92	89	87	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55	53	52	50	48	47	45	44	42	41	39	38	36	35	34	32	31	30	29	27	
146	97	95	92	90	87	85	82	80	78	75	73	71	69	67	65	63	61	59	57	56	54	52	50	49	47	45	44	43	41	40	38	37	36	35	33	32	30	29	28	27
148	97	95	92	90	87	85	82	80	78	76	73	71	69	67	65	63	61	60	58	56	54	53	51	49	48	46	45	43	42	40	39	38	36	35	34	32	31	30	28	28
150	98	95	92	90	87	85	82	80	78	76	74	72	70	68	66	64	62	60	58	57	55	53	51	49	48	46	45	43	42	41	39	38	37	36	34	33	31	30	29	28
152	98	95	93	90	88	85	83	81	79	76	74	72	70	68	66	64	62	60	59	57	55	53	52	50	48	47	46	44	42	41	40	39	37	36	35	33	32	31	30	29
154	98	95	93	90	88	85	83	81	79	77	74	72	70	68	66	65	63	61	59	57	56	54	52	50	49	47	46	44	43	42	40	39	38	37	35	34	33	32	30	29
156	98	95	93	90	88	85	83	81	79	77	74	72	71	69	67	65	63	61	59	58	56	54	53	51	49	48	46	45	43	42	41	40	38	37	36	34	33	32	31	30
158	98	95	93	90	88	86	83	81	79	77	75	73	71	69	67	65	63	61	60	58	56	55	53	51	50	48	47	45	44	43	41	40	39	38	36	35	34	33	31	30
160	98	95	93	90	88	86	83	81	79	77	75	73	71	69	67	65	64	62	60	58	57	55	53	52	50	49	47	46	44	43	42	41	39	38	37	35	34	33	32	31
162	98	95	93	90	88	86	84	82	80	77	75	73	71	69	68	66	64	62	60	59	57	55	54	52	51	49	47	46	45	44	42	41	40	39	37	36	35	34	32	31
164	98	95	93	91	88	86	84	82	80	78	75	73	72	70	68	66	64	62	61	59	58	56	54	52	51	49	48	47	45	44	43	41	40	39	38	36	35	34	33	32
166	98	95	93	91	88	86	84	82	80	78	76	74	72	70	68	66	65	63	61	59	58	56	54	53	51	50	48	47	46	44	43	42	41	39	38	37	36	35	33	32
168	98	95	93	91	88	86	84	82	80	78	76	74	72	70	68	67	65	63	61	60	58	56	55	53	52	50	49	47	46	45	43	42	41	40	39	37	36	35	34	33
170	98	95	93	91	89	86	84	82	80	78	76	74	72	70	69	67	65	63	62	60	59	57	55	53	52	51	49	48	47	45	44	43	41	40	39	38	37	35	34	33
172	98	95	93	91	89	86	84	82	81	78	76	74	73	71	69	67	66	64	62	60	59	57	55	54	53	51	50	48	47	46	45	43	42	41	39	38	37	36	35	34
174	98	95	93	91	89	87	84	83	81	78	76	75	73	71	69	67	66	64	62	61	59	57	56	54	53	51	50	49	47	46	45	43	42	41	40	39	37	36	35	34
176	98	96	94	91	89	87	85	83	81	79	77	75	73	71	70	68	66	64	63	61	60	58	56	55	53	52	50	49	48	46	45	44	43	42	40	39	38	37	36	35
178	98	96	94	91	89	87	85	83	81	79	77	75	73	72	70	68	66	64	63	61	60	58	56	55	54	52	51	49	48	47	46	44	43	42	41	39	38	37	36	35
180	98	96	94	91	89	87	85	83	81	79	77	75	73	72	70	68	67	65	63	62	60	58	57	55	54	52	51	50	48	47	46	45	43	42	41	40	39	38	36	35
182	98	96	94	91	89	87	85	83	81	79	77	75	74	72	70	68	67	65	63	62	60	59	57	56	54	53	51	50	49	48	46	45	44	43	42	40	39	38	37	36
184	98	96	94	92	89	87	85	83	82	79	77	76	74	72	70	69	67	65	64	62	61	59	57	56	55	53	52	50	49	48	47	45	44	43	42	41	39	38	37	36
186	98	96	94	92	90	87	85	83	82	80	78	76	74	72	71	69	67	66	64	62	61	59	58	56	55	53	52	51	49	48	47	46	44	43	42	41	40	39	38	37
188	98	96	94	92	90	87	85	84	82	80	78	76	74	73	71	69	68	66	64	63	62	59	58	57	55	54	52	51	50	49	47	46	45	44	43	41	40	39	38	37
190	98	96	94	92	90	88	85	84	82	80	78	76	75	73	71	69	68	66	65	63	62	60	58	57	56	54	53	51	50	49	48	46	45	44	43	42	41	39	38	37
200	98	96	94	92	90	88	86	84	82	80	79	77	75	74	72	70	69	67	66	64	63	61	60	58	57	55	54	53	52	51	49	48	47	46	45	43	42	41	40	39

Hammer-Welding Plant of the Blaw-Knox Co.

New Plant and Process for Making Large Seamless Tanks and Sheet-Steel Vessels Described by Tracing the Course of an 8-Ft. Boiler Shell of 7/8-In. Plate Through Its Manufacture

By ERNEST EDGAR THUM

IN A FOREGOING article[1], entitled "Welding, Particularly Hammer Welding," a general survey was given of the various methods now in common use for joining metals into a continuous substance. It was noted that all the new methods extended the use of welding to joints which would not be attempted by the blacksmith.

Hammer welding is an adaption of the methods of the smith to quantity production and to pieces so large that they are entirely unmanageable without adequate mechanical handling. Consideration of the fundamentals indicated that a mechanical welding operation, simulating hand-forging, must heat the pieces rapidly to the correct temperature without oxidation, and quickly hammer the hot metal together, continuing the work to recalescence. Transfer of tools or heated metal must be very rapid. The work must be firmly held. Finally the completed article must be bodily put into an annealing furnace, to relieve internal strains and refine the grain.

Such operations must remove as many as possible of those empirical conditions which are so difficult to control in handwork and which make it remarkable that so many welds are good, not that a few are very bad.

While any forge shop which has applied the principles of modern metallurgical control to welding under the steam or drop hammer may justly claim to practice hammer welding, and while a brief description of the Navy's excellent plant for making anchor chain was included in the former article, it would be better at this time to restrict the term to the welding of long seams in plate work. The advantages of "seamless" containers for volatile gases and fluids are obvious. Equally apparent must be the utility of welded vessels which must withstand wide variations in temperature and pressure. Welded pipe should be an attractive material for lines offering a minimum frictional resistance to flow of liquid.

Perhaps half a dozen concerns in the United States are now equipped to turn out this material. However, information regarding their equipment and the process has been closely held. Considerable credit, therefore, is due to the officials of the Blaw-Knox Co. and the National Tube Co. for their broad-mindedness in opening their plants for inspection.

What follows is a description of the operating technique of the Blaw-Knox Co. Thanks are due to Messrs. Lehman and Leitelt, vice-president and engineer respectively of that concern, for their helpful co-operation.

Blaw-Knox Plant

Briefly, the method for hammer-welding seams in use in the Blaw-Knox Co. is as follows: The various plates, bent or pressed to shape, are assembled with lap joints, and stitched together here and there by a short torch weld on the edge. The assembly is then placed on a carriage, joint up. A pair of gas flames are held one above the seam and the other directly below. When that region has been brought to a proper heat, the upper and lower torches are quickly replaced by an air hammer and anvil respectively, and the hot spot welded and worked down flat. This cycle is repeated until the seam is welded continuously from end to end. When all the seams are finished, the whole article is annealed; all fixtures applied, and if it is a pressure vessel, it is subjected to hydraulic test.

A plant for negotiating such heavy work naturally has many machine tools and handling devices for storing, shaping, assembling and testing. While interesting, such equipment can hardly be regarded as a part of the welding machinery, and it will be passed with brief mention.

Material is stored at one end. The yard is covered by a 70-ft. span crane of 10-ton capacity. The main shop itself is divided into two aisles, one 70 ft. wide and the other 40 ft. Most of the latter is occupied by the welding machinery, but some is partitioned off for a power house and tool room. In this space are located a motor generator set and switchboard, an air compressor, a high-pressure pump and accumulator for the hydraulic system and a repair shop holding a carefully selected group of machine tools.

Plates measuring more than 1-in. thick are not welded without scarfing, and a modern edge planer with a 20-ft. throat is installed for this purpose. Near by is a very powerful bending roll. It is four-roll set with ability to bend cold plates 20 ft. wide by $\frac{3}{4}$ in. thick, and hot plates $1\frac{1}{4}$ in. thick. These rolls are driven by a 100-hp. electric motor. The center roll of the lower three is supported by hydraulic rams so as to give the proper "squeeze" to the plates in bending. This machine is not only used in forming plates prior to welding but also for re-rolling afterward in order to give a true cylindrical shape to circular work, especially at the seam. For this purpose the end housing is hinged to the foundation, so that an open-ended shell can be slipped under the top roll.

Dished ends, flanged plates and domes are cut to correct shape and pressed, either hot or cold, in another department, well equipped with heating furnaces, flanging rolls and hydraulic presses for this kind of work. Such operations are a common feature of all boiler work, and no special notice need be given them here.

Welding Operation

An operation may perhaps best be described by tracing the course of a boiler shell, say 8 ft. in diameter by 15 ft. long.

A square plate of appropriate size is selected, and the

[1] Chem. & Met. Eng., vol. 25, No. 12, Sept. 21, 1921, p. 553.

edges brushed vigorously with a wire brush to remove any dirt or loose rust. (It is not necessary to have the metal bright before welding, since some oxide is reduced during heating, and the rest melted or fluxed. It is largely ejected during the first hammer blows, but extreme care is necessary to eliminate it substantially from the finished joint.) The plate is then rolled into a cylindrical tube of correct diameter, and so that the edges overlap a distance about the thickness of the plate. On completion of this cold work, the end roll housing drops, and the plate is removed by one of the 10-ton overhead cranes commanding the building.

It is apparent that an exact closure at a long seam made in the rolls is impossible, owing to the fact that there will be a narrow strip of straight, unbent plate along each edge. The plates therefore lap over each other in a blunt angle. Such a seam may often be welded immediately, especially if the bent plate is stiff enough so that there is little tendency for the two edges to spring apart when they are hammered. Shorter seams, heads and smaller fixtures are attached by screw clamps,

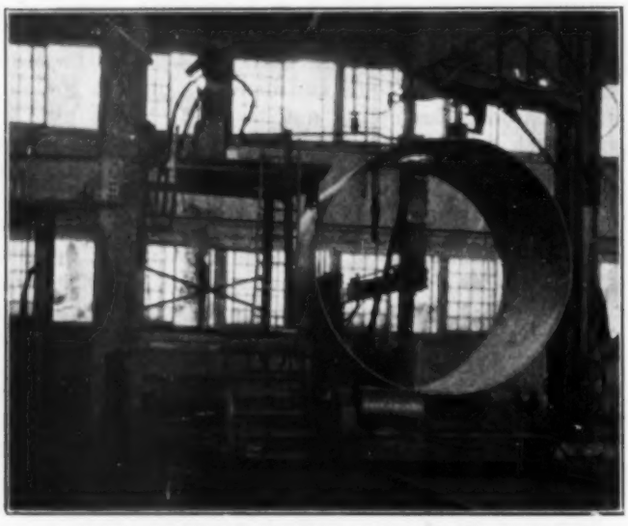

FIG. 1. CARRIAGE FOR HANDLING WORK

and "tacked" on by a workman with an oxyacetylene flame. He builds up short fillet welds at intervals of 3 or 4 ft. Then the joint is ready for the welder.

As noted above, in welding work as bulky and heavy as this, it is necessary to bring the fire to the work rather than *vice versa*. This does not obviate the necessity of closely controlled manipulation of the work, however. Blaw-Knox engineers have therefore designed several different carriages for this purpose, one of the simple ones being shown in Fig. 1. There have been electrical controllers installed on the pulpit at the left whereby the carriage is moved bodily forward or back, the cradle may be lifted, or moved to either side; and finally the rollers cradling the work may be rotated without changing their position in space. Thus the operator has three motions of translation and one of rotation at his command, which allows him quickly and surely to adjust the work so that it may rest at exactly the proper angle on the anvil and a blow may be struck in exactly the proper direction.

As may be seen from Figs. 1 and 2, the heating and hammering machine consists essentially of two pivoted arms carrying burners, another with an anvil; a fourth may carry the air hammer, although in the views shown it is held by a jib crane. With the pipe

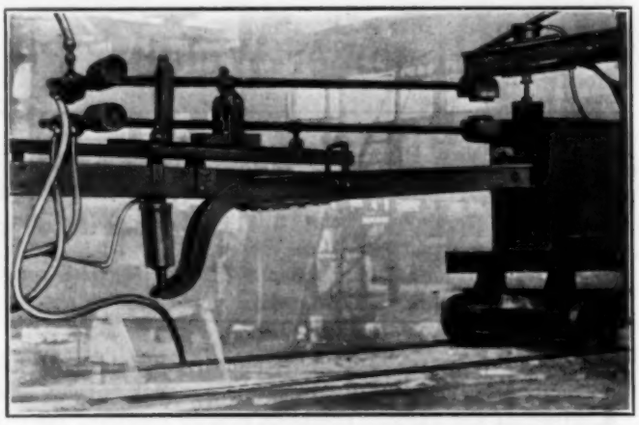

FIG. 2. HEATING AND HAMMERING MACHINE

properly placed on the carriage, the two burners are swung into position, one just above and one just below the spot where welding is to begin. Fig. 3 is a sketch of these burners, which consists of a box where the gas and air is properly mixed, and a firebrick tuyere, luted in place with refractory clay. The two heavy pipes carrying gas and air serve as supporting arms. In place, the foreman signals an assistant at the rear end of the machine, the gas valve is opened, and the fuel ignited by a small pilot flame. Almost immediately the air valve is opened, quickly reaching the correct amount, when the flame "pops" back to the tuyere, burning in a short, non-luminous roaring flame, completely filling the space between burner and plate, and flaring out along the steel for 6 in. or more on all sides (Fig. 1).

About five minutes is required to reach a welding heat on a 12-in. seam in ¾-in. plate. Temperatures here might readily and advantageously be read by optical pyrometer. Fine sand or borax may be used as a flux,

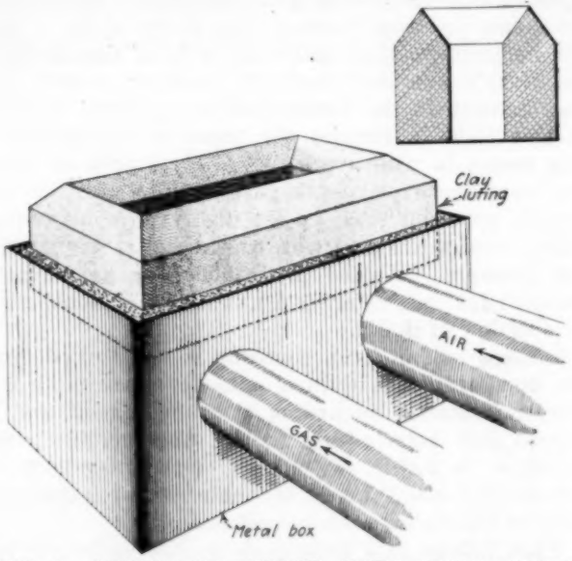

FIG. 3. SKETCH OF BURNER, WITH BRICK TUYERE IN PLACE

but if the flame is held with a slight deficiency of air, little trouble from slag or oxide is to be expected in low-carbon metal. As the welding heat is approached, molten slag will drip from the metal—in fact the plate itself will be slightly fused at projecting corners. The burners, which are nicely pivoted and balanced, are then swung to one side, the gas and air turned off, and their place immediately taken by the anvil or "horn"

beneath and the hammer above. Inspection of Figs. 1 and 2 will show that both of these fixtures are held on very stout, stiff arms, properly pivoted and actuated by air cylinders so that they can be jammed into place with great dispatch and accuracy. It is necessary that the anvil reach its exact position in bearing over the whole hot spot, especially when welding around blunt corners, else the hammer will merely beat the metal out of shape without effecting a weld. It is understood of course that corner work requires special anvils—the anvil used is in all cases shaped to the contour of the inner surface of the object.

First light blows of the hammer are directed at the corner of the sheet, gradually working across the weld, ejecting any molten material in a sheet of white hot sparks. High-speed blows at full air pressure are continued until the temperature has fallen to a faint red, when the force of the blow is lightened, but continued down through the recalescence temperature to a

FIG. 4. DEPHLEGMATOR MADE BY HAMMER WELDING

black heat. The hammer itself is swung so it is moved back and forth by the foreman during this operation; the pipe meanwhile resting solidly on the horn, inertia in the hammer cylinder and arm absorbing the reaction from the blow. Air at 100-lb. per sq.in. is the motive power; the cylinder is 5 in. in diameter, the stroke is 11 in., and a blow is struck 160 times per minute.

About half the length heated is welded in this operation, but in thick plate the region must be reheated and hammered twice more before the combined sheets are worked down to the thickness of the rest of the shell. This produces a lap joint which is at least 3 in. long in any sheet thicker than $\frac{3}{8}$ in. Flux is more liberally used in the second and third heatings. When this spot is finally joined to the foreman's satisfaction, the carriage is shifted and the same cycle of operations repeated on the continuation of the seam.

Thus a cylinder is welded from end to end. As a final operation, it is replaced in the bending rolls, they are adjusted to give the exact curvature required, and the seam rolled back and forth several times to bring this portion to correct shape.

If one end is to be closed, as in Fig. 4, the dished and flanged end sheet[2] is tacked in correct position by five or six short fillet welds, the work then placed on the carriage so that the burner and anvil arms reach into the pipe through the open end. One portion of a circular seam is then welded in the regular way; the pipe rotated on its cradle and a diametrically opposite portion finished. Intervening sections are then closed and welded. Large stills such as shown in Fig. 5 can be made, the bottom entirely solid, and the top having a manway not less than 18 in. in diameter, the minimum opening necessary for burner and anvil. Small openings and fixtures such as brackets are often welded in place by an oxyacetylene flame.

[2]Flanging is arranged so that the ends fit over the sides; heating and hammering operations are then conducted so as to close the flange in to correct diameter, avoiding any expansion of the shell.

Fuel Gas

Water gas is used for the burners at the Blaw-Knox plant. Other gases have been tried elsewhere, but often with indifferent success. While water gas (approximately 46 per cent H_2 and 43 per cent CO) produces a relatively low amount of heat on perfect combustion, it requires but a small amount of air with a corresponding small proportion of nitrogen and consequently gives a very hot flame, as shown in Table I.[3]

TABLE I. CHARACTERISTICS OF GASEOUS FUELS

Gas	Calorific Power Calories per Cu.M.	Volumes of Air for Combustion	Temperature of Flame, Deg. C.
Natural gas (Pittsburgh)	8,423	9.35	1,852
Oil gas	7,350	7.74	1,915
Coal gas (illuminating)	5,550	5.79	1,896
Coke-oven gas	5,159	5.36	1,892
Carburetted water gas	5,008	5.02	1,914
Water gas	2,590	2.24	1,924
Ordinary producer gas	1,300	1.13	1,555

The small amount of air required for combustion is of greater advantage in another way—it is much easier to get a quick and intimate mixture of gas with, say, two volumes of air than with nine or ten volumes, as would be required for natural gas. Unless the gases are correctly mixed, certain portions of the flame would have a great excess of oxygen, with fatal results to a welded joint. In fact, one of the chief excellences of a

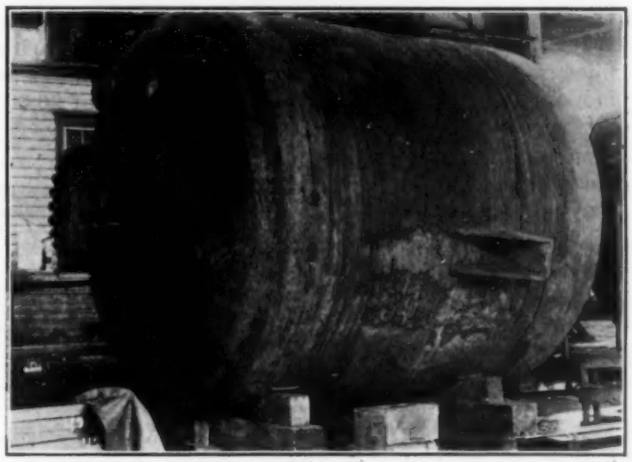

FIG. 5. SEAMLESS STILL FOR CRACKING GASOLINE

smith's fire is the fact that his thick bed of incandescent charcoal effectually prevents the passage of any air until its oxygen has combined at least to carbon dioxide.

Gas is generated in two units built by the United Gas Improvement Co. of Philadelphia, using coke as a fuel. It is not necessary to devote space for an exposition of

[3]From Richards' "Metallurgical Calculations," vol. 1, p. 190.

the gas manufacture. In practice, the producer is run about one minute on air blast, heating the coke, and wasting the products of combustion. Then a series of valves are changed, requiring about fifteen seconds, and steam is blown through the hot column of fuel, decomposing it into H_2 and CO, the fuel gas. In about three minutes the coke has been so cooled by the reaction that another heating period is necessary. Fig. 6 shows a plan of a typical water-gas generating plant, which corresponds closely to the layout at Blaw-Knox, except that the "blow-up" gases are wasted rather than passing through waste-heat boilers as shown, steam being available elsewhere.

Coarse dust is removed by passing the gas through a water-sealed cyclone dust catcher, and then scrubbed

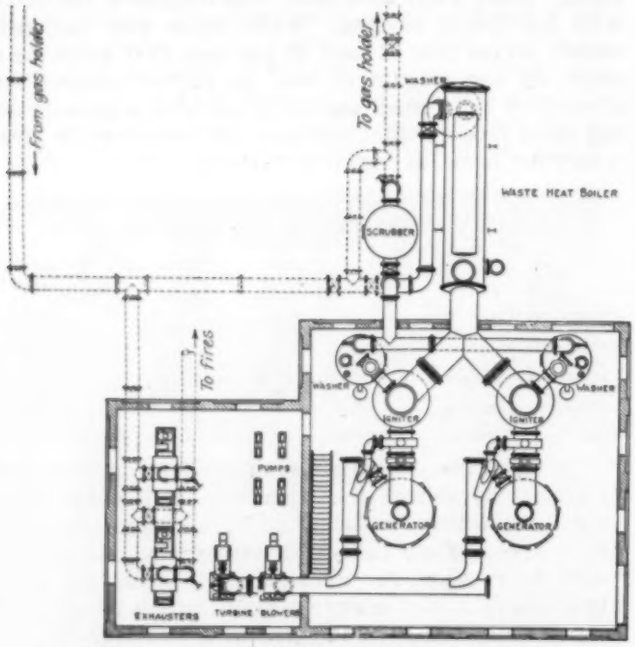

FIG. 6. WATER GAS GENERATING PLANT

free of finer particles and cooled in a column filled with trays over which water is sprayed. A final purifier filled with wood shavings and rusty iron turnings removes any sulphur compounds. A gas holder of 30,000-cu. ft. capacity acts as a reservoir, from which gas is drawn by an impeller blower, and delivered through a 12-in. main at 1.5-lb. pressure, controlled automatically. Air for combustion is also pumped through a 12-in. main by a similar Roots blower, at 1.5 lb. per sq.in.

After a pipe or tank—in fact any pressure vessel or article to work under anything greater than nominal load—has been completely welded, it is heat-treated. An annealing furnace (Fig. 7) large enough to receive work 6 x 9 ft. in size and 20 ft. long was furnished by Tate, Jones & Co., Inc., for this purpose. It is equipped with ten main and ten auxiliary burners, arranged for either oil or natural gas. Variation in temperature in the furnace is held to within 30 deg., as registered by pyrometers installed at eight different points in the furnace. A unique feature of the installation is a door which when opening sinks into a pit so as not to interfere with the crane when handling large circular work in and out of the furnace.

Welded articles are heated gradually to about 75 deg. above their upper critical, thus relieving working stresses and refining the grain. Considerable variation in the relation between strength, hardness and ductility is possible, as is well known, by proper control of heating times, temperatures, and cooling rates. It is unnecessary to expand on this point, important though it be, for the principles of heat-treating low-carbon steel articles are the same, whether the piece be hammer welded or merely forged.

Tests on Welds

The excellence of well-made seams joined in this manner is becoming generally acknowledged. Numerous tests of hammer-welded joints have been made, and seldom show an efficiency less than 90 per cent of the strength of the material. It is reasonable to expect high strength from such joints, since the method used evidently does much to remove those three chief causes of defects in forge-work—viz., insufficient care and labor by the smith, poor control of the heating flame and temperature of the work, and lack of accurate heat-treatment of the finished piece.

Blaw-Knox Co. in its boiler shop has a test pit and high-pressure pumps for testing closed tanks, and in addition the hammer-welding department contains a long testing press for proving open-ended pipes up to 6 ft. in diameter and 40 ft. long at any pressure under 1,500 lb. per sq.in. After a pressure of 50 to 100 per cent in excess of the working load has been applied, the seam is struck vigorously several times with a 10-lb. sledge. This would not only lay bare many a defect which would not be detected by a static load, but actually subjects the whole structure to a considerable impact, as is evident by the pressure gage jumping about 100 lb. at each blow. It is important to note that such testing should never strain the vessel much more than 80 per cent of the proportional limit of the material, otherwise the metal will become somewhat brittle due to cold work.

Fig. 8 shows a pot for annealing wire which after completion was tested somewhat above its elastic limit. Well-marked Lüder's lines were then found to cover the entire surface, passing through the longitudinal and circumferential welds (whose general position is shown by the arrows) without appreciable distortion. This is a very elegant demonstration of the homogeneity of

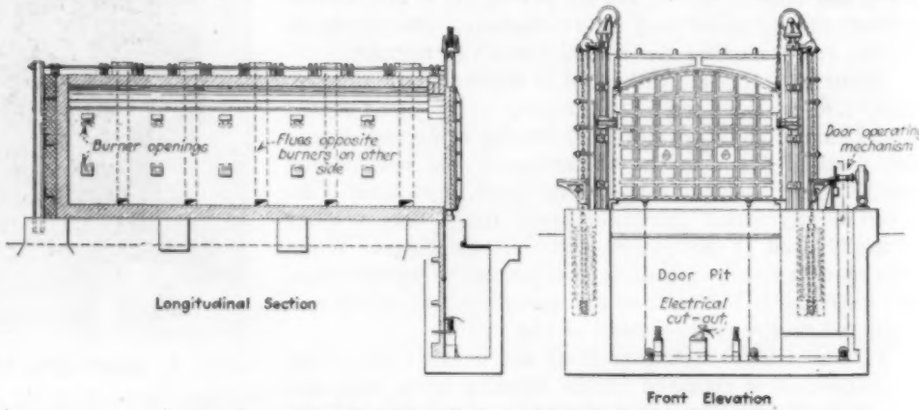

FIG. 7. ANNEALING FURNACE FOR LARGE TANKS

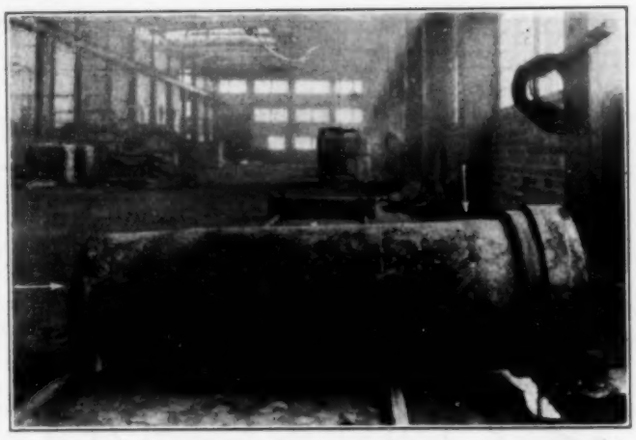

FIG. 8. LUDER'S LINES CROSSING WELD ON POT OVER STRAINED IN TESTING

weld and body plate. Another evidence of quality in the weld is the fact that many annealing pots similar to this have been made of straight pipes, the double bell at the top having been expanded without injury or extra stretch at the weld.

Welded Articles

Modern industry requires vessels which withstand considerable temperature or mechanical strains and yet remain impervious to penetration by contained fluids or surrounding gases. Blaw-Knox Co. specializes in the manufacture of such articles.

Thin wire and sheet must be annealed during and after manufacture. A small amount of surface oxidation would be fatal, especially as the gage becomes finer and finer. Cast-iron annealing pots, with a carefully sealed lid, have been the standard utensil for guarding against this danger, but they warp badly on many reheatings, finally becoming impossible to seal effectively. Furthermore they are very heavy. Consequently hammer-welded annealing pots are gaining favor rapidly.

Riveted stills and tanks for volatile and light oils have given much trouble. No matter how carefully riveted and calked, the continual "weaving" of plate on plate caused by temperature variation in a setting, or by the jars incident to transportation, is almost certain to cause leakage, especially of the lighter fractions which penetrate almost microscopic openings. Such leaks have caused disastrous explosions or great losses in transit, and can be entirely overcome by hammer-welding.

Other heating vessels should be close to size and seamless in order that the heat conduction should be uniform throughout, or that there may be close clearance between walls and stirring or other mechanism. Cast vessels are thick, brittle and unsafe under any but moderate pressures, and hammer-welding is undoubtedly able to produce containers which will allow the designer of digesters and similar apparatus a much greater leeway.

Canadian Soap Industry in 1918

According to a report that has been issued recently by the Dominion Bureau of Statistics, Canada produced 108,316,748 lb. of soap in 1918, practically the whole of which was consumed in the dominion, only a little more than 1,000,000 lb. being exported. The dominion produced practically all its own requirements, only a trifle more than 5,000,000 lb. being imported.

The Pyrolysis of Some Hydrocarbons

By Fred Denig

THE purpose of this investigation was to determine the decomposition and vapor pressures of hexane, gasoline, kerosene and vaseline.

Vapor pressure data are of immense value to the refinery engineer in the design of pressure stills, cracking apparatus, etc. Such data are also of use to the internal combustion engineer who is interested in the history of the hydrocarbon during compression just before combustion. Roy Cross[1] published some curves several years ago showing the relation between pressure and temperature of several hydrocarbon mixtures when subjected to heat. These curves are about the only ones published and available to the average engineer interested in petroleum. It was thought desirable to recheck his values and to cite the distillation curve of the gasoline studied, which he failed to do. The curve for hexane has been determined, since engineers are prone to use this compound in many calculations involving gasoline. Vaseline was studied in order to determine whether it would decompose into fixed gases or into gasoline- and kerosene-like substances.

The bomb used in the investigation was furnished by H. L. Doherty & Co. through the active interest of D. G. Brandt. It consists of a cylinder 17 in. long, 4

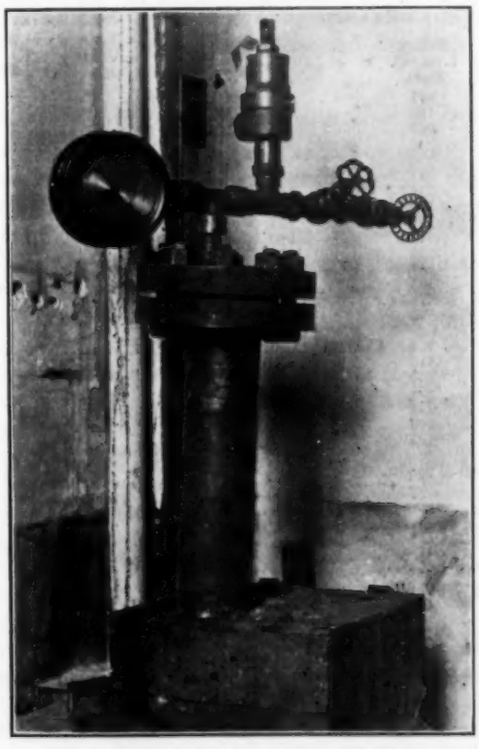

FIG. 1. EXPERIMENTAL BOMB

in. outer diameter and 3¼ in. inner diameter. Fitted to the cylinder was a collar 1½ in. thick. A head plate served as a cover, having a groove cut into it to fit the cylinder. A ring of soft copper was fitted into the groove. The collar and head were drawn together by means of eight ½-in. bolts. The approximate volume of the bomb was 2 liters. The bomb was made of shell steel and had been tested out to 7,000 lb. per sq.in.

[1] "The Cracking of Petroleum in the Liquid Phase," Met. & Chem. Eng., vol. 16, 1917, p. 643. See also Kansas City Test. Lab. Bull. 15, p. 226.

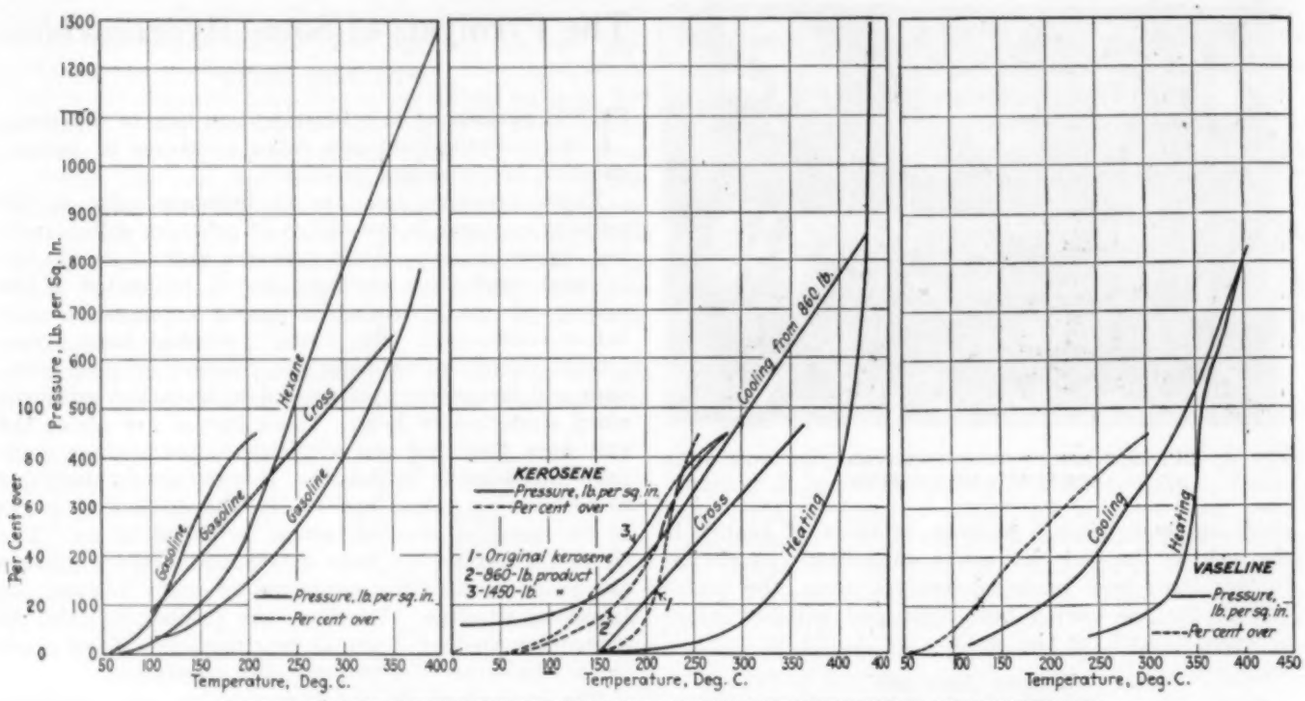

FIG. 2. VAPOR PRESSURE OF HEXANE, GASOLINE, KEROSENE AND VASELINE

TABLE I. VAPOR PRESSURE OF HEXANE

Time	Temp. Deg. C.		Pressure Corr. Lb. Sq.In.
12:45	Start		....
1:15	145		85
1:21	180		165
1:26	200		255
1:30	210		305
1:35	230		400
1:40	243		485
1:45	255		565
1:50	275		665
1:55	293		775
2:00	315		870
2:05	335		970
2:10	347		1,025
2:15	365		1,100
2:20	375		1,160
2:25	390		1,215
2:30	400		1,280
2:55	360	Cooling	1,080
3:10	310		870
3:25	280		685
3:35	255		590
3:48	235		435
4:10	200		305
5:15	125		95

No residual gas pressure.

The bomb was charged with 500 c.c. of hexane. The hexane was Kahlbaums hexane (normal), redistilled, and the fraction taken that distilled within a range of ±2 deg. C. of 69 deg. C. It is to be noted that the hexane was not absolutely pure, but the best that could be obtained under the circumstances. Indeed it was the same hexane that Ipatiev used in his studies on the decomposition of hexane.

TABLE II. VAPOR PRESSURE OF GASOLINE.

Time	Temp., Deg. C.	Pressure Corr. Lb. Sq.In.
1:15	Start	....
1:45	105	35
1:50	140	55
1:55	165	90
2:00	190	130
2:05	210	170
2:10	230	205
2:15	245	245
2:20	255	275
2:25	265	300
2:30	280	345
2:35	290	370
2:40	300	400
2:45	310	435
2:50	320	470
2:55	327	505
3:00	335	535
3:05	340	565
3:10	350	610
3:15	360	645
3:20	365	685
3:25	370	715
3:30	375	755
3:35	380	790

No residual gas pressure.

Distillation curve of final product exactly the same as the original. Specific gravity of gasoline used 0.7457 at 23 deg. C. Distillation gave (See Fig. 2):

Deg. C.	Per Cent Over	Deg. C.	Per Cent Over
60	..	133	40
80	5	143	50
94	10	155	60
106	15	170	70
109	20	184	80
120	30	210	90

TABLE III. VAPOR PRESSURE OF KEROSENE

Time	Temp., Deg. C.	Pressure Corr. Lb. Sq.In.
8:00	Start	....
9:00	270	35
9:10	295	65
9:20	300	75
9:40	320	110
9:50	335	145
10:00	340	175
10:10	365	215
10:20	375	255
10:30	387	290
10:40	395	325
10:50	400	365
11:00	405	400
11:10	410	460
11:20	415	545
11:30	425	625
11-35	426	680
11:40	427	755
11:45	430	850
11:50	432	950
11:55	435	1030
12:00	435	1140
12:10	435 Shutdown	1440

500 c.c. was heated to 860 lb. pressure and the mass cooled, several points were taken on the cooling curve and are plotted as dotted line on the kerosene curve.

4:05	430	860
6:00	210	215
7:00	90	75
Next day	20	60

The original kerosene has a sp.gr. of 0.800 at 24 deg. C. Distillation gave (see Fig. 3):

Original, Deg. C.	Per Cent Over	After Heating to 860 lb. Deg. C.	After Heating to 1,450 lb Deg. C.
150	5	60	50
		111	100
196	10	133	136
204	20	169	136
214	30	192	156
218	40	208	180
224	50	217	198
229	60	227	215
235	70	240	232
243	80	258	254
257	90	285	285

Analy is of gases from the heats:

	After Heating to 860 Lb. per Cent	1,450 Lb. per Cent
Hydrogen	25.0	64.0
Methane	48.0	33.5
Ethylene	27.0	2.5

TABLE IV. VAPOR PRESSURE OF VASELINE

Time	Temp., Deg. C.	Pressure Corr., Lb. Sq.In.
7:30	Start	...
8:30	190	...
8:42	237	35
8:59	260	45
9:00	285	70
9:05	310	95
9:10	327	135
9:15	335	180
9:20	343	260
9:25	350	335
9:30	353	425
9:35	360	515
9:40	367	580
9:45	375	625
9:50	380	650
9:55	382	670
10:00	387	700
10:05	392	735
10:10	395	760
10:15	400	800
10:20	405	815
10:50	355	565
11:02	320	425
11:10	300	355
11:20	270	275
11:30	250	215
11:45	230	150
12:00	190	100
12:15	170	75
1:15	115	15

Analysis of fluid mass in bomb after heat to 860 lb. distillation gave (see Fig. 4):

Deg. C.	Per Cent Over	
54	..	420 c.c. of liquid
100	10	recovered, sp.gr. >
115	20	0.830 at 25 deg. C.
145	30	The fraction distill-
165	40	ing below 300 deg. C.
185	50	contained 8.8 per
210	60	cent by volume of
240	70	olefins and 20 per
268	80	cent by volume of
+300	90	aromatics.

Four liters of gas was obtained, with the following analysis:

	Per Cent
Hydrogen	67.0
Ethylene	8.7
Methane	25.0

Weight of free carbon deposited, 22g

The bomb was charged with 454 g (1 lb.) of vaseline. The vaseline had a specific gravity of 0.876 at 22 deg. C.

hydraulic pressure by the makers. The head plate contained an opening for a bull nipple for the pyrometer couple and another opening for a ¾-in. nipple that connected to the fittings. As shown in Fig. 1, this nipple is connected to a tee, which in turn was connected to a pressure gage on one side and a pressure release valve and valves on the other side.

When cold no trouble was experienced in making the bomb tight and able to resist high pressures. However, when heated all joints were found to leak. Various expedients were tried to relieve the trouble. Finally we welded the bull nipple and the ¾-in. nipple to the head of the bomb. For the leaks in all other connections we applied thin rings of soft copper. From that time on we had no further trouble with leaks.

The bomb was placed in a Case gas muffle furnace. The upper limit of temperature was 425 deg. C., due to

the large amount of radiation from the walls of the furnace and the head of the bomb which protruded from the furnace.

To measure temperature a thermo-element of constantin-iron was used. The pyrometer was carefully calibrated before and after the experiments.

An American steam gage recording up to 3,000 lb. was used throughout the experiments. The gage was calibrated before and after the experiments, and a correction curve drawn. The corrections on this curve were the mean of the corrections as determined by the two calibrations.

Method of Procedure

A sample of the hydrocarbon was placed in the bomb and heated. Pressure and temperature observations were made at frequent intervals, and both heating and cooling curves obtained. The volume of gas formed was noted and the gas analyzed, and the liquid remaining was distilled and the fractions corresponding to the gasoline and kerosene cuts were treated for unsaturated compounds by the sulphuric acid[2] test and for aromatics.[3] The tests applied were empirical in nature and serve only to give a general idea as to the constitution of the substances obtained.

All experimental values are tabulated on the accompanying tables, and curves showing the *P–T* relations are drawn for each substance. The curves for gasoline and hexane are shown on the same plot in order to show the marked difference in vapor pressures.

Hexane

The curve for the vapor pressure of hexane has been determined experimentally up to 400 deg. C. (See Table I and Fig. 2.) Ipatiev[3] heated hexane in a bomb quite similar to the one used in this experiment and states that at 510 deg. C. the hexane decomposes with explosive violence. In this paper he did not give the pressure-temperature data that he usually gave when he worked on the pyrolysis of different substances. For this reason it was determined in this experiment. Due to the large size of the bomb 425 deg. C. was the limit of temperature obtainable in the furnace used.

Gasoline and Kerosene

In examining the *P–T* curve for gasoline (see Table II and Fig. 2), it is to be noted:

1. No decomposition took place throughout the range that the gasoline was heated, the product obtained after heating having exactly the same distillation curve as the substance placed in the bomb, and the cooling curve being exactly the same as the heating curve. Had the gasoline "cracked" the cooling curve (*P–T*) would lie above the heating curve.

2. The curve obtained is not a straight line, or in other words gasoline vapor does not follow Boyle's law. This fact is mentioned because Cross[4] apparently obtained a straight line relation. He does not state whether he obtained his curve by experiment or by calculation.

Examination of the kerosene vapor pressure curve (see Table III and Fig. 2) shows a sharp bend upward. This sudden change in direction of the curve indicates decomposition. Analysis of the product after heating shows the same fact. The decomposition point of kerosene is very close to its boiling point, so naturally decomposition is expected. It is interesting to note that Cross also obtained a straight line as he did in the case of gasoline.

Vaseline

Vaseline was studied in order to determine whether it would break down into a large amount of fixed gases or whether it would form a large amount of light products and a relatively small amount of fixed gases. (See Table IV and Fig. 2.)

The vaseline broke down almost completely to gasoline and kerosene, 81 per cent by volume being recovered. Of this fluid mass found in the bomb 34 per cent distilled off within the gasoline range—i.e., below 150 deg. C.—and 54 per cent distilled within the kerosene range—i.e., between 150 and 300 deg. C. The combined gasoline and kerosene fractions contained by volume 20 per cent of aromatics and about 9 per cent olefins. This may be explained by the work of Ipatiev, who heated ethylene under pressure and found that the gas polymerized at a temperature range of 350 to 400 deg. C., producing paraffins such as hexane, heptane octane, higher olefins and cycloparaffins, together with high-boiling products of an unsaturated character. Probably what happens can be best explained by simply assuming that the vaseline breaks down into the lower hydrocarbons, principally ethylene and hydrogen. The ethylene immediately polymerizes into cyclic and aromatic compounds, as well as into the paraffins.

Polymerization

There is much that remains to be studied about polymerization and it deserves much more intensive study than has been given to it. It will probably explain as much as our present-day theory of "cracking." Pressure is probably the greatest factor in influencing polymerization. For instance, when kerosene was heated to 860 lb. pressure, the gas contained 27 per cent olefin, the fluid 14 per cent gasoline, while when the pressure was allowed to rise to 1,450 lb. and at practically the same temperature, the gas contained 2.5 per cent olefin and the liquid 25 per cent gasoline; the theory being, of course, that at the increased pressure the olefins rapidly polymerized into gasoline-like substances.

New Method for Drying Clay

Pottery plants at Devon and Cornwall, England, are now using a new method for drying clays, in which two metal drums are employed, one inclosed in the other. The inner drum is driven by mechanical means, and while revolving, steam enters it at a few degrees above the temperature of boiling water. The clay is passed into the outer drum and comes into contact with the inner drum as it revolves, filled with steam. The water in the clay is evaporated and the clay dried quickly, the process being one measured in minutes. The waste steam, with temperature lowered through operation, is passed back to the boiler and utilized again under increased temperature. The labor saving in the new method, it is said, is considerable. The clay is fed into the drum automatically. The space requirements are only about one-eighth or one-tenth of the regular demands, and 1 ton of coal will dry about 45 tons of clay under the mechanical system described, as compared with about 8 to 10 tons by the customary method.

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[2] Kansas City Test. Lab. Bull. 15, pp. 335, 336.
[3] Ipatiev, *Ber. Deutsch. chem. Gesell.*, vol. 44, pp. 2978 and 2987 (1911).
[4] Met. & Chem. Eng., vol. 16 (1917), p. 643.

Electrolysis vs. Retort Smelting for Zinc*

By Frederick Laist

IT MAY be stated that the electrolytic zinc process is applicable to a great variety of ores and concentrates. Almost any ore containing zinc can be treated, although, of course, it does not necessarily follow that the operation of extracting the zinc will be profitable.

When we first undertook the development of the electrolytic process at Anaconda for the beneficiation of our complex zinc-lead-copper-silver ores and the utilization of our surplus water power, I had very little idea that such a process could be applied commercially except when the concentrates were low grade and water power was obtainable at low cost. Later we found that we could purchase high-grade concentrates originating in the West in competition with retort plants; in fact, it is probably not too much to say that the future of the zinc business in the West is going to depend to a considerable extent on the development of electrolytic zinc.

Future of Electrolytic Zinc

With the development of the process and the extension of our operations, my optimism as to the future of electrolytic zinc has steadily grown, until now I am not sure that we will not yet see electrolytic plants operating on high-grade concentrates and actually producing their power by the combustion of coal or oil or gas.

This statement may seem somewhat extreme, but it is based on the following general premises:

1. The fuel required for distillation and reduction of a ton of zinc in a modern retort plant will, when burned in an efficient modern power plant, generate sufficient electric energy to deposit a ton of zinc from sulphate solution.

2. The labor required for producing a ton of zinc electrolytically from a given concentrate will be no more than one-third the labor required by the furnace method.

3. The total investment required to produce a ton of zinc electrolytically will, in general, be little, if any, greater than by distillation—it being assumed, of course, that both plants are constructed with a view to permanence.

4. The great purity of electrolytic zinc and the desirable qualities which it possesses by reason of its purity will, as they become better known, give electrolytic zinc a distinct advantage on the market to the detriment of less pure grades of zinc.

While the correctness of the above premises has not been absolutely proved, I have from time to time come into possession of data which lead me to believe that in the main they are not far off. An accurate comparison can, of course, be made only where all local conditions are known, such as character of ore to be treated, cost and kind of fuel, unit construction costs, etc.

Advantage of the Process Over Retort Process

A very important advantage of the electrolytic zinc process over the retort process, and which I have purposely not included in the above, as I wish to speak of it more at length, is better recovery. There has been a good deal of misunderstanding as to the recovery realized in existing electrolytic plants and a certain amount of disappointment has been manifested at the apparently low recovery being made. At Great Falls, for example, the recovery is approximately 80 per cent; at Trail it is lower than this. This 80 per cent average recovery is, however, made up of recoveries of about 75 per cent on low-grade concentrates containing 30 per cent to 35 per cent zinc on the one hand and 85 per cent to 90 per cent on high-grade concentrates containing 50 to 55 per cent zinc on the other. In other words, the possible recovery depends entirely on the grade and composition of the concentrates undergoing treatment, and the actual recovery depends as well on the design of the leaching equipment and the facilities for washing. I have not the slightest hesitation in saying that on pure, high-grade Joplin concentrates a well designed roasting and leaching plant can make a recovery of 92 to 95 per cent of the zinc content, and that in general on any given grade of concentrate a better recovery can be made than is commercially possible by distillation.

It goes without saying that a lower grade concentrate can be successfully treated, since the operating costs of the electrolytic process are more nearly proportional to zinc content than those of the distillation process and the presence of lead and iron is much less detrimental.

Experimental Work Carried On

The recovery of zinc from low-grade, and to a lesser extent, from high-grade concentrates is one of the things which is receiving considerable attention at the present time, and the future will see great improvement in this direction. Experimental work is being carried on along two lines:

1. To cut down losses of insoluble zinc by more careful control of roasting, and to improve extraction and washing by better design of leaching plant equipment and flowsheet.

2. By subjecting residues to additional treatment for recovery of both soluble and insoluble zinc.

The latter development is particularly important where the residues are to go to the lead smelter, as the presence of zinc in such residues, apart from representing an economic loss in itself, is highly detrimental to the subsequent smelting operation. Its removal and recovery would, therefore, be a very decided step in advance. Experimental work at Anaconda and Great Falls indicates that a recovery of 75 per cent of the zinc in the residue may be expected, which would bring the over all recovery on even a low-grade (30 to 35) concentrate between 92 and 94 per cent.

Ability to Treat Fines

Another important advantage of the electrolytic process is its ability to treat fines. Whether we like it or not, the flotation process is bound to be resorted to more and more for the production of zinc concentrates, and these are necessarily very fine. So far from being a detriment as in the firing process, this condition is a positive advantage to the new process, so that at Great Falls we have in the past actually limited our purchases of outside material to flotation concentrates.

Where acid is to be manufactured, the less complete roast required for the wet process may present certain advantages and might under favorable conditions make unnecessary the use of muffle furnaces. Obviously, from the standpoint of recovery the presence of sulphur in the form of SO_3 is not detrimental. The only possible disadvantage from too much sulphate in the

*Extracts from an address given before the meeting of the American Zinc Institute, May 10, 1921.

calcine is the building up of acid in the solution system to the point where a discard of cell acid must be made. This actually happens at Great Falls and results in the loss of a small percentage of zinc. Both the acid and the zinc could be saved by evaporation of a small portion of the cell solution each day, and this will probably be done.

From what has been said, you can see that electrolytic zinc has made quite remarkable progress in the six years that have elapsed since the commencement of the experimental work on which the existing plants are based. From a war baby it has grown into an industrial process which has demonstrated its ability to produce zinc in competition with older processes and has unquestionably come to stay.

Technically, both metallurgically and mechanically, the existing plants are far from perfect, and much remains to be done. In all departments improvements can be made which will result in better recovery, better current efficiency and lower operating and plant costs. Such improvements are not problematical, but certain, and in many instances already roughed out.

A British View on Steel Foundry Furnaces

A CONTRIBUTION to *The Engineer*, Aug. 5, 1921, says that the starting of a foundry for the production of small steel castings presents many difficulties by reason of the many different factors in the problem which have to be taken into consideration. For example, electric steel, by virtue of its freedom from gases and great purity, together with its high pouring temperature, seems well suited for the making of very thin and light castings, especially so if the steel is run directly from the furnace spout to the molds. Furnaces of 1-ton capacity are possibly the most suitable size. Compare this proposal with the crucible process, which is also suitable for the purpose in view. The pots are usually of about 90-lb. capacity—larger pots have generally been abandoned. The steel can be obtained exceedingly hot, fluid, and free from gas, and if a proper selection of the raw metals is made the resultant steel is as free from impurities as electric steel. The making of very thin section castings presents no difficulty.

A very small electric furnace would be necessary were it desired to pour the whole contents economically with the furnace at its highest temperature. To transfer the whole charge to one large ladle and from it to fill the molds would be less satisfactory owing to the steel chilling, and the steel would tend to set before the whole charge was cast. On the other hand, the crucibles can be taken straight from the crucible holes, at their highest temperature, just when wanted.

Furthermore, several small electric furnaces, say of 1-ton capacity, would be necessary to obtain a large output of exclusively small castings, and the cost of operating small electric furnaces is relatively high. In the crucible process, on the other hand, the weight of metal per pot is standard, and the cost is not affected by the size. Hence a comparison of the two methods may result in favor of the crucible, but there are, nevertheless, particular cases in which the electric furnace has the advantage.

The bessemer system, with converters up to 1 or 2 tons capacity, also has its advocates, who claim many advantages over the two previous processes for the production of small steel castings, particularly when side-blown converters are used. The total tonnage may be kept down to 1 ton, and the temperature may be made very high if necessary by the addition of high grade silicon after the initial heat from the original charge has been attained. Small converters, as compared with electric furnaces of similar capacity, could deliver over five times the tonnage in an equal time, and the quality may be as high. The success of the converter primarily depends upon the operator. A skilled blower can be relied upon to put charge after charge into the foundry well up to the schedule. With low sulphur and phosphorus in the charged materials, these objectionable elements need not be high enough to influence the quality unduly. Abnormally low sulphur and phosphorus can, of course, be obtained in the electric furnace, but it is only rarely that such extreme purity is required, and at a cost which purchasers will pay only in exceptional circumstances.

The usual bottom-blown bessemer and side-blown converter produce similar qualities of steel. Generally the side-blown converter produces the more fluid steel for small work, but the refining losses are from 5 to 10 per cent greater than in the bottom-blown converter. It is generally supposed that the "blown" process always absorbs unlimited quantities of oxides. This may occur with overblown charges, but rarely happens when the process is in the hands of skilled operators. As a matter of fact, with weighed additions of ferrosilicon and manganese, etc., the attainment of specified physical tests and analyses to specifications presents no difficulty.

The Open-Hearth Furnace

The usual open-hearth furnace is not so successful for small castings. The extremely high temperature required cannot be obtained consistently without destroying the refractories and generally shortening the life of the furnace. The most successful type of open-hearth for small work is the Siemens special rapid, with a capacity of 1 ton. The producers are built on to the end of the furnace—the flame describing a horseshoe bend before passing back through the same end on the way to the regenerators. The ferrosilicon and manganese are allowed to melt on the banks and run down into the bath. The carbon is somewhat high—from 0.60 to 0.80 per cent, and occasionally up to 1 per cent. The steel is poured directly from the furnace. The furnace is tapped—great care being taken to keep the tap hole and the flow of metal not too large.

The furnace tap hole may be opened and closed many times in the course of a heat, the steel being kept hot in the furnace in the meantime. The refining losses are small, but high carbon, instead of higher temperature and lower carbon, condemns this process for many classes of small castings. This type of furnace, however, has been used extensively with great success for the production of colliery castings. The steel with low carbon is too sluggish and cold for casting small work, but with the addition of manganese excellent manganese steel can be obtained.

The basic bessemer and basic open-hearth furnaces are not a success for the production of small castings.

That the old method of crucible steel making can still more than hold its position against modern methods has been clearly proved, and there are large buyers of small castings who have tried all processes, but

return to their former founders—the crucible steel maker. The quality of crucible steel may be due to the protection of the molten steel from oxidizing gases, which is usually exhausted by charcoal addition, and also by the protection afforded the metal by the slag which may be in contact with a neutral atmosphere.

The price of small steel castings is generally governed by the amount of core making, molding, size and the difficulty in running, etc. Providing the castings are clean and of ample strength for their proposed use, analysis is rarely called for. Special prices are paid for alloys and special carbon castings, but there is only a very small demand for these things.

Generally speaking, the very costly and expensively operated plants cannot insure any higher price for their products on the recommendation of slightly lower sulphur and phosphorus. Specialists can obtain high prices, but steel founders are not all specialists. They have to consider their various inquiries carefully in view of their own risks and their competitors' prices.

Instrument to Measure Elongation of Broken Tensile Specimens

By R. W. Woodward*

ANYONE who has made a large number of tensile tests of metals is well aware of the awkwardness and other difficulties encountered in the usual method of measuring the elongation of a broken tensile specimen. This method generally consists of holding the matched ends of the specimens in the hands or laying them on a bench, setting a pair of dividers to the distance between previously punched gage marks inclosing the fracture, and measuring the distance apart of the divider points by a scale graduated in hundredths of an inch. Obviously by this procedure the fractured ends are not held together as tightly as possible and the measured elongation is somewhat too large. Furthermore the reading of the setting of the dividers from the graduated scale is attended with some difficulties, and blunders are often made. Also the simple operation of dividing the measured elongation by the gage length to obtain the percentage elongation is susceptible of mistakes and in checking computations is quite often found to be wrongly performed.

To overcome the first-named source of error many laboratories use a clamping device to hold the broken specimens, but still measure the elongation by means of dividers and scale. The instrument described in this paper was designed to eliminate as far as possible all the above sources of error and is a direct-reading instrument for obtaining the percentage elongation of a fractured specimen.

It consists of a bed plate upon which are mounted a fixed head stock with a movable center and an adjustable tail stock, as shown in Fig. 1. By this means specimens up to a total length of 9 in. can be rigidly held together, eliminating all gap at the fracture. Above the specimen is a slide carrying two index points. One of these indices is fixed to the slide, while the other is movable on the slide. The movable index carries a pinion which engages a rack on the slide. Fastened to the pinion shaft is a pointer which moves over the scale graduated into fifty divisions. The rack and pinion are such that one revolution of the pinion advances the index exactly 1 in. The pointer is set at zero when the indices are exactly 2 in. apart; one revolution of the pointer then corresponds to a movement of 1 in., or for a 2-in. gage length, to 50 per cent elongation.

In operation the slide is moved until the fixed index is set into one gage mark. (There are light springs on the indices to keep them normally above the specimen.) The movable index is then slid along the rod until it fits into the other gage mark. The reading of the pointer then gives directly the percentage elongation. The elongation may be readily determined with an accuracy of ± 0.1 per cent, while with the ordinary method the best that can be obtained is ± 0.5 per cent.

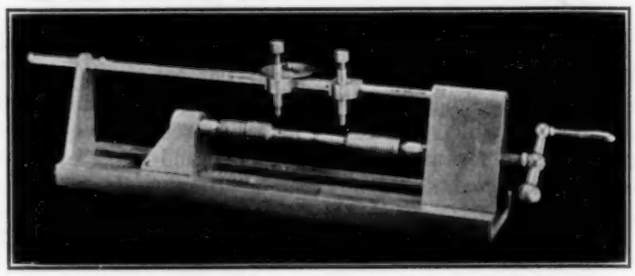


FIG. 1. MACHINE FOR MEASURING ELONGATIONS

The following table shows the applicability of the instrument and represents elongation values obtained by the methods noted on ten specimens taken at random from a large number of the type shown in Fig. 1.

	Per Cent Elongation Measured by		
Specimen	Special Instrument	Dividers, Specimen Held in Hands	Dividers, Specimen Held in Clamp
Q6A	21.7	22.5	21.5
Q8A	22.4	23.0	23.5
M8	22.1	23.0	22.5
V8A	25.2	25.0	25.0
R6C	24.4	24.5	24.0
Q9C	19.1	19.5	19.0
A1A2	6.0	6.5	6.0
P4A	25.8	26.0	25.5
R2C	19.8	20.0	19.5
R8C	21.7	21.5	22.0
Average	20.82	21.15	20.85

These readings were all taken independently without a knowledge of the values obtained by the other methods. They show that high values for elongation are obtained unless the specimen is held in some form of a clamp. Incidentally in this short series of measurements the value for the elongation of Q8A for the method given last in the table was first read off the scale as 0.42 in. instead of 0.47 in., as later inspection of the results show it should have been. This is an inexcusable blunder, but one that is certainly bound to occur at times.

The time taken to obtain the above measurements was also observed, but was found to be practically the same for all methods—namely, six to seven minutes. However, if the elongation is measured on opposite sides of the specimens, a gain in time as well as in accuracy will be noted.

The advantages claimed for this instrument are:

1. Elimination of sources of errors and blunders.
2. Greater sensitivity in the measurement of elongation.
3. Greater reliance can be placed upon the results.
4. A saving in time.

While the instrument described here[1] is designed to take 2-in. gage length specimens, by a simple change of dials it can be adapted to other gage lengths.

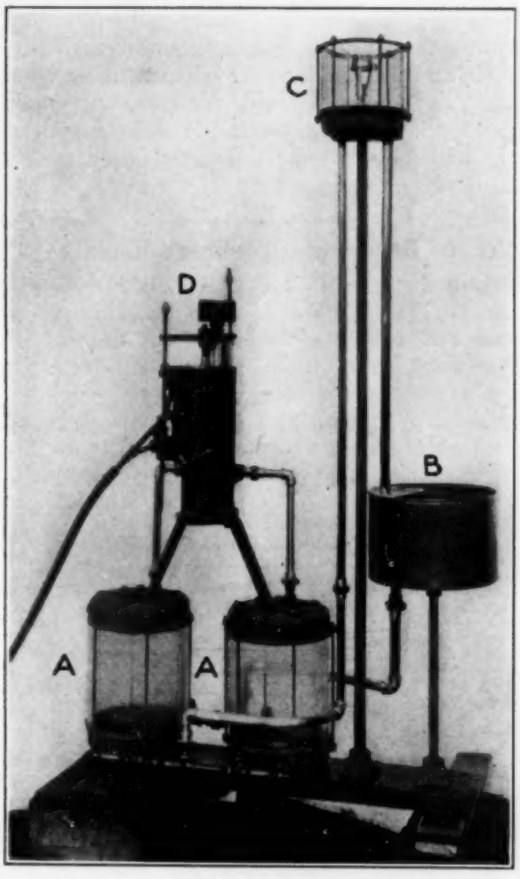
*Physicist, U. S. Bureau of Standards.

[1]Arrangements have been made whereby this instrument will be placed on the market by the Tinius Olsen Testing Machine Co. of Philadelphia.

Displacement Pump for Elevating Acid by Compressed Air

ORDINARY simple or even compound air lifts have their limitations for handling acids and other chemical solutions owing to the low factor of submergence frequently encountered. The saturation of the air by the acid has also resulted in undesirable fumes and in losses due to precipitation at the point of discharge.

These difficulties are avoided in the Sullivan displacement pump, a small demonstration model of which is shown in the accompanying figure. The pump consists



DISPLACEMENT PUMP FOR ACID

of two cylinders or tanks, *A*, *A*, with a common inlet and a common discharge opening, each provided with check valves. The tanks fill by gravity from the source of supply, *B*, and are alternately emptied of their contents by direct air pressure which carries the liquid being pumped to the desired elevation, *C*. The filling and emptying of the tanks is controlled by the Sullivan automatic switch, which is placed above the level of the acid and operated by air from a line independent of that which supplies the tanks. The operation of the switch, by alternately admitting compressed air to each tank, secures a continuous discharge of acid into the storage tank or basin.

The characteristics of this new pump are:

The liquid to be pumped does not come in contact with any moving parts, such as floats, except the inlet and discharge check valves.

Clearance losses are avoided, since the automatic switch leads the expanded air from the empty tank into the full cylinder before admitting live air to the latter, thus filling the lines and clearance spaces.

Power and time losses in overcoming inertia are obviated by this method of reusing the exhaust air, thus starting the acid before live air is admitted.

The speed of switching is governed effectively by an accessible valve, without other adjustment.

The air pressure to the switching apparatus is regulated by an independent diaphragm reducing valve, securing positive and equal timing of the switch movement, regardless of the pressure in the air receiver.

There is no precipitation loss or emulsification of the acid being pumped. The compressed air does not mingle with the liquid, but merely exerts direct pressure upon its surface.

The pump and exposed parts may be made up of steel, cast iron, bronze or other materials designed to resist the chemical action of the acid to be handled.

Pumps may be supplied for any capacity and lift, and for liquid of any specific gravity, within a wide range.

New Brown Cold Junction Compensated Pyrometer

THE Brown Instrument Co., Philadelphia, Pa., is placing on the market a new thermo-electric pyrometer, which is automatically compensated in the instrument for changes in cold junction temperatures and which includes means of setting the pointer of the instrument to zero in the usual manner.

This is an improvement on the method of cold junction compensation developed by Darling in England in 1909, and an improvement on a few subsequent developments for automatic cold junction compensation brought out since that time. These former methods afforded no means of setting the intsrument to zero. It is customary on all electrical instruments, including millivoltmeters and pyrometers, to supply a zero adjuster to enable the user to set the instrument to zero, provided the zero has shifted, due to jars in transportation or with continual service.

Darling used what is called a Briguet spiral, a compound strip of two metals of different coefficient of expansion. The Briguet spiral was used to move the scale dependent on the change in atmospheric temperature surrounding the instrument, or as an alternative this Briguet spiral was mounted to act on the springs controlling the moving element of the galvanometer. Darling's device was never used to any extent, because it was evident that unless an instrument had a means of setting to zero, serious errors might result in the use of the instrument. Suppose, for example, the instrument pointer was standing at 110 deg. F., was the pointer standing at this position on the scale because the temperature surrounding the instrument was 110 deg. F., or was the temperature surrounding the instrument only 90 deg. F. and had the zero shifted 20 deg.? Naturally, no accurate temperature instruments could be obtained with this element of doubt.

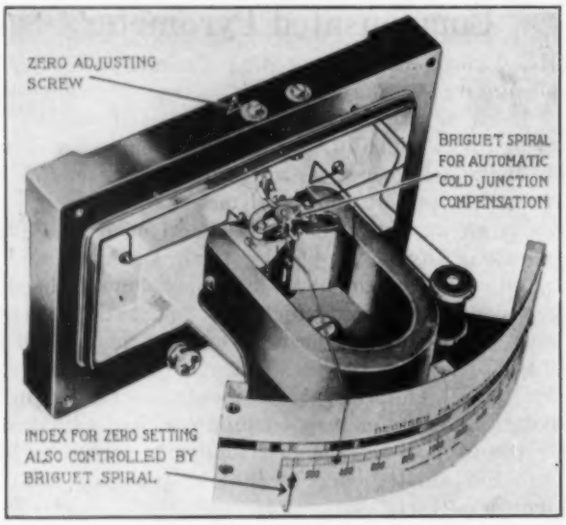
The new Brown construction patented Dec. 28, 1920, includes a means of setting the instrument to its proper zero. This is clearly set out, for example, in claim 1, as follows: "In an electrical instrument, a pointer, a scale operatively arranged with respect to said pointer, means to automatically compensate said scale for changes in temperature surrounding said instrument and means for establishing a normal zero, whereby said pointer can be set to zero."

It is generally understood by all users of thermo-

electric pyrometers that the millivoltage or emf. developed by a thermocouple is dependent on the difference in temperature between the hot and cold ends of a thermocouple. To get accurate measurements of temperature, it is therefore necessary that the cold end of the thermocouple be maintained at a constant temperature or the instrument must be compensated for the changes in temperature at the cold junction of the thermocouple.

It is common practice to use what are known as extension or compensating leads, formed of material similar to the thermocouple, which will transfer the cold junction from the binding posts of the thermocouple to a distant point. Heretofore it has been necessary to locate the cold junction at the end of the extension or compensating leads in a cold well in the ground or in a compensating box, where the temperature can be maintained constant.

If the new Brown pyrometer, compensated for changes in temperature of the cold junction, is used,


ZERO ADJUSTING SCREW
BRIGUET SPIRAL FOR AUTOMATIC COLD JUNCTION COMPENSATION
INDEX FOR ZERO SETTING ALSO CONTROLLED BY BRIGUET SPIRAL

INTERIOR VIEW OF BROWN COMPENSATED PYROMETER

the extension or compensating leads are brought to the meter. Changes in temperature at the end of the extension or compensating leads also take place in the meter itself, which can be compensated for this change in temperature.

There are two methods by which this compensation can be easily obtained. A portion of the scale of the instrument may be mounted on thermostatic material and moved, dependent on the change in temperature of the meter, and in this way automatic compensation may be had. Only a portion of the scale is moved and an index on the other portion of the scale denotes the normal zero of the instrument.

A Briguet spiral similar to that used by Darling may be mounted in the instrument, controlling the springs and moving element directly, and a second index controlled by thermostatic metal may be mounted on the scale. This index works with change in temperature exactly in relation to the movement of the pointer controlled by the Briguet spiral attached to the moving element.

In using the new Brown pyrometer, it is only necessary to bring the compensating or extension leads from the thermocouple to the instrument. After mounting the instrument, the instrument pointer is set by the zero adjuster to correspond with the index on the scale. If the values for a thermocouple have been determined, based on a cold junction of 75 deg. F., the index will indicate 75 deg. F., provided the instrument is subject to this surrounding temperature. If the instrument pointer does not correspond with this index, it is set accordingly. When the temperature surrounding the instrument and the cold junction of the end of the compensating leads at the instrument rises to 90 deg. F., the index automatically rises to 90 deg. F., and the Briguet spiral attached to the instrument pointer causes it to move up to 90 deg. F., automatically adjusting for the temperature of the cold junction of the thermocouple.

It will be understood that any number of thermocouples with their extension or compensating leads can be brought to the one instrument having this automatic compensation. Likewise, recording instruments can be equipped with this automatic compensation and means for setting the pointer to zero.

Census Report on Phosphate Rock, 1919

Phosphate rock to the value of $10,300,198 was produced in the United States in 1919, according to figures just made public by the Bureau of the Census. Sixty-five per cent of the total production came from Florida. Thirty per cent of the total production was mined in Tennessee. The remaining 15 per cent was produced in South Carolina, Idaho, Kentucky and Utah. The detailed figures, as given out by the Census Bureau, are:

Number of enterprises	48
Number of mines	69
Number of enterprises operating beneficiating plants in connection with mines	20
Mineral lands operated, total (acres)	160,447
Persons engaged in industry, total	4,761
Proprietors and firm members	14
Salaried employees	374
Wage earners (average number)	4,373
Wage earners Dec. 15 or nearest representative day:	
Above ground	5,764
Below ground	149
Power used (horsepower)	49,639
Capital	$72,733,956
Principal expenses:	
Salaries	761,423
Wages	3,900,966
Contract work	163,696
Supplies and materials	2,161,501
Fuel	1,739,833
Power	79,468
Royalties and rents	209,687
Taxes	347,580
Expenditures for development (included in the above items)	353,237
Products, total value[1]	$10,300,198
Phosphate rock:	
Quantity (tons, 2,240 lb.)	1,988,975
Value at mine	$10,292,990

Selected Bibliography on Oil Shale

A "Selected Bibliography on Oil Shale," compiled by E. H. Borroughs, bibliographer, and M. J. Gavin, oil shale technologist, has just been issued by the United States Bureau of Mines. The bibliography, which is designated as Serial 2,277, refers to about 300 articles, papers, reports and treatises bearing on the technology of oil shale, and selected chiefly from the literature of the years 1915-20. The references cited cover the oil shales of the entire world, and relate to the history of the industry; the geographic occurrence and geology of shale deposits; methods of mining, retorting, refining and utilization; the properties of shale and their determination; statistics of the industry; legislation and legal regulations; and economics. Copies of Serial 2,277 may be obtained free by addressing the Director of the Bureau of Mines, Washington, D. C.

[1] Includes value of other minerals produced and the amount received for miscellaneous work, services and power furnished other enterprises.

Current Events
in the Chemical and Metallurgical Industries

Dinner to Delegates From American Engineering Societies to Great Britain and France

The homecoming of the delegates from the American Engineering Societies who went to Great Britain and France to present the John Fritz medal to Sir Robert Hadfield and to Eugène Schneider was celebrated by nearly two hundred engineers at a dinner Monday evening, Oct. 10, at the Hotel Pennsylvania, New York City. Representatives of the British and French governments and of foreign engineering societies gave the event an international aspect unique in gatherings of engineers.

J. Vipond Davies, president of the United Engineering Society, acted as toastmaster. Messages were received from Herbert Hoover, Sir Robert Hadfield, Eugène Schneider, the Institution of Civil Engineers, the Institution of Mining and Metallurgy and Mining Engineers, Captain Riall E. Sankey, president of the Institution of Mechanical Engineers; Magnus Howett, secretary of the Institution of Mechanical Engineers; the British Iron and Steel Institute, Engineers Club of London, Faraday Society, Viscount James Bryce, Arthur Neal, Member of Parliament from Sheffield; Jesse Merrick Smith, and A. E. Kennelly, exchange professor to France. The speakers were Ambrose Swasey, Charles F. Rand, F. B. Jewett, A. S. Dwight, John R. Freeman, all members of the deputation; Captain G. H. Armstrong, British Consul General; Gaston Liebert, French Consul General; G. C. Clapperton, representing the British Institution of Electrical Engineers, and Prof. Jacques Cavalier, spokesman for the French universities. The closing feature of the evening was the presentation by Gaston Liebert, the French Consul General at New York, of medals struck by the French Government in commemoration of the entente cordiale between the engineering societies of both countries to the following engineers: George S. Webster, Philadelphia, president of the American Society of Civil Engineers; Edwin Ludlow, New York, president of the American Institute of Mining and Metallurgical Engineers; Edwin S. Carman, Cleveland, president of the American Society of Mechanical Engineers; W. McClellan, Philadelphia, president of the American Institute of Electrical Engineers; Charles T. Main, Boston, chairman of the A.S.C.E. delegation; A. S. Dwight, New York, chairman of the A.I.M.E. delegation; Ira N. Hollis, Worcester, Mass., chairman of the A.S.M.E. delegation; F. B. Jewett, New York, chairman of the A.I.E.E. delegation, and Ambrose Swasey, Cleveland, general chairman of the deputation.

Protest Distilled Spirits Tax

Drug, industrial alcohol, flavoring extracts and confectionery interests have joined in a protest to the Finance Committee of the Senate against the proposal of the majority members of the committee to levy a flat tax of $6.40 a proof gallon on distilled spirits, with a rebate of $4.20 a proof gallon where it is shown that the spirits are to be used for non-beverage purposes. It was stated that such a proposal is not acceptable to the industries requiring pure ethyl alcohol in the manufacture of its products for the following reasons:

1. The House bill did not increase the tax on alcohol from $2.20 per proof gallon, but provided for an additional tax of $4.20 on each proof gallon to be paid by the person responsible for diversion of the spirits to beverage purposes. This, substantially, is as it should be, and legitimate manufacturers are not concerned in such penalty, regardless of the amount thereof. The proposal of the majority members of your honorable committee, however, would make law-abiding citizens criminals until they proved themselves innocent.
2. Said proposal would tie up for an interminable period vast capital—as an illustration, approximately $1,500,000 annually in the case of Parke Davis & Co., Detroit, alone—without ultimately adding one penny to the Treasury of the United States or aiding in the enforcement of prohibition and without recompense to lawful business for interest, additional clerical help and counsel fees incidental to keeping accounts and prosecuting claims for rebate; and in this connection consideration should also be given to the inevitable increased cost to the ultimate consumer of medicines, food products and other necessaries of life in the manufacture of which alcohol is an essential factor.
3. Said proposal would unquestionably put out of business innumerable small merchants and manufacturers doing a reputable business but not possessing or able to borrow the necessary additional capital to finance themselves pending uncertain adjustments of alcohol rebate accounts.
4. As taxes on distilled spirits under existing law are payable by the distiller or proprietor of the bonded warehouse on withdrawal from bond and are sold to the trades tax-paid, said proposal if otherwise practicable, leaves open the question of how and by whom the $4.20 is to be legally claimed by way of rebate.
5. Generally speaking, said proposal is based upon the theory that if all distilled spirits are lawfully used, the Government will receive only the present rate of $2.20 per proof gallon, and that any additional revenue will come from those who violate the Eighteenth Amendment to the Constitution and the national prohibition act; therefore, from a national standpoint, what is gained by penalizing legitimate industry and making more expensive indispensable articles of commerce, especially when the integrity and lawful operations of manufacturers using alcohol in their processes are investigated before the federal prohibition commissioner issues to them the basic permit to obtain and use alcohol and exacts bond (obtainable only at exorbitant rates of premium) in a penal sum practically double the non-beverage alcohol tax involved and conditioned upon their lawful use of the chemical?
6. Said proposal is a prohibition measure pure and simple and will neither produce additional revenue nor add a tithe of discouragement to bootleggers, who could not obtain a drop of alcohol if the prohibition unit of the Internal Revenue Bureau administered effectively the national prohibition act, the purposes of which are well stated in its very title—viz: "An act to prohibit intoxicating beverages, and to regulate the manufacture, production, use, and sale of high-proof spirits for other than beverage purposes, and to insure an ample supply of alcohol and promote its use in scientific research and in the development of fuel, dye, and other lawful industries."
7. In the final analysis, why not encourage industry in the lawful use of a chemical raw material of paramount importance which is already taxed many hundred per cent above its cost of production and thereby materially increase the revenue?

The protest is signed by the American Drug Manufacturers' Association, the American Pharmaceutical Manufacturers' Association, the National Wholesale Druggists' Association, the National Association of Retail Druggists, the Manufacturing Perfumers' Association, the Proprietary Association, the Flavoring Extracts Manufacturers' Association, the National Confectioners' Association and the Industrial Alcohol Manufacturers.

Copper Shingle Production

The Anaconda Copper Mining Co. has established a department at its Washoe plant at Anaconda, Mont., for the manufacture of copper shingles, copper-zinc shingle nails and affiliated specialties, in an effort to broaden the market for copper products. The present production for the most part is of purely experimental character.

Further Data on the Oppau Disaster

According to a statement made by the Badische Anilin und Sodafabrik, in another warehouse at Oppau no less than 7,000 tons of sulphonitrate of ammonium (the compound which caused the damage in the recent explosion) remained absolutely intact, although the walls of the building were blown in and glowing fragments fell right into the contents.

A witness affirms that on the day of the catastrophe preparations had been made for splitting up a block of the compound by means of explosives. On the other hand, the double explosion leads experts to think that possibly the first explosion outside the warehouse, presumably in the neighboring sulphonitrate of ammonium factory, was the result of completely unknown causes, and that the principal explosion was brought about by fragments scattered by the first explosion.

As to the practice of blasting the hardened masses of the product, it is said that this operation had been carried out about 20,000 times at the Badische works and elsewhere and had been performed only the day before in the very warehouse in which the explosion occurred.

La Liberté of Paris learns from a highly qualified chemist who visited the works at Oppau two days after the catastrophe that it is a mistake to suppose that the explosion will have any notable effect on the German output of fertilizers and dyes. In the first place, the dye works, which are situated at a distance of 2 kilometers from the site of the explosion, suffered little damage and work was scarcely interrupted. Within a radius of 250 meters nearly all buildings were completely destroyed; from 250 to 500 meters serious damage was caused; beyond 500 meters nothing but reparable damage occurred. It is reckoned that in three months' time the production of ammonia and the manufacture of fertilizers can be resumed as previously.

As for the cause of the disaster, the French chemist said that he could offer no explanation. The salt in question, he was informed, was manufactured at the works before 1914 and numerous experiments had been made in order to test its non-explosiveness; it had been placed in barrels and set on fire, for instance, or an electric spark had been passed through it, but no sign was ever detected of any danger of explosion.

Recent Advances in Plant Chemistry

About one hundred members of the Rochester Section of the American Chemical Society met at Hobart College, Geneva, N. Y., Oct. 1. Prof. J. E. Lansing, director of the department of chemistry, discussed in a very interesting way the teaching of chemistry at Hobart College from 1822 to the present day, and Dr. Thatcher spoke on "Recent Advances in Plant Chemistry," in part as follows:

Undoubtedly the most serious handicap which biochemists have had in the attempts to study or duplicate the chemical processes which take place in cell protoplasm lies in the fact that we have thus far been compelled to work with mixtures of reagents in solution, contained in beakers, test tubes, etc., in which ionization and diffusion make a uniform chemical change throughout the entire reacting mass practically unavoidable. Recent advances in our knowledge of the colloidal condition make it plain, however, that even in so small a mass as the protoplasmic contents of a single cell there are thousands, if not millions, of colloidal compartments, separated from one another by membranes of variable and perhaps constantly varying permeability, in which a great variety of chemical changes may go on independently of each other.

It would seem to me, therefore, that the first requisite for up-to-date study of the chemistry of living things is a recognition of the structure of the cell as an essential factor in its synthetic operations, and that the first advancement toward an understanding of and possible duplication of the cell synthesis will require the successful reproduction of a colloidal mass having similar structure to that of cell protoplasm.

I believe that a proper mental picture of the organization and activity of a plant cell is suggested by the figure of a well-organized chemical factory, with the different transformations which are involved in the whole process going on in different parts of rooms of the factory, with the raw materials systematically transported from one room to another as they are needed to keep each step in the whole process going at the proper rate, and with all the different parts of the whole factory working in smooth coordination with one another.

The raw materials for this factory are the mineral matter and water coming from the soil and the gases of the atmosphere; the intermediates are the simple carbohydrates and amino-acids; and the finished products comprise all of the varied compounds which are the results of cell protoplasmic activity and which are used by the plant for its nutrition, growth or reproduction.

The researches of botanists and chemists in the past have dealt with the nature of the compounds and the chemical changes which are involved in each separate process of the factory's operation. The principal problem now is to learn the nature and method of superintendence of the factory, whereby its operations are automatically regulated and altered so as to provide the proper output of all the varying products of the factory to meet the needs of the whole plant. We are as yet almost wholly in the dark concerning the regulatory agencies which control the rate and character of the synthetic processes of cell operation. We call these regulatory agents "catalyst," or "enzymes"; but as to what they are and how they act we know very little.

Furthermore, we have absolutely no idea, as yet, of the methods of intercommunication and of recognition of supplies and needs of raw materials or finished products whereby the factory output is varied in kind or quantity.

A further aspect of plant chemistry, the significance of which is easily apparent from the simile of the factory, is that chemical changes which are almost the exact antithesis of each other are going on simultaneously in every active plant organism, if not indeed in each individual plant cell. The synthetic production of complex organic compounds and the destructive oxidation of previously produced synergic foods to furnish energy for the synthetic processes go on simultaneously; just as, in any factory, there is consumption of fuel, wearing out of equipment, etc., during the process of manufacture of the factory output. This phenomenon, too, is readily understood on the basis of colloidal structure and emphasizes again the importance of recognition of this condition of matter as a necessary step in studies of protoplasmic activities.

New Jersey Chemists Meet

About 150 members attended the first regular meeting of the New Jersey Chemical Society at Newark on Oct. 10. Dr. H. E. Howe, chairman of research extension division of the National Research Council, talked on the history, organization and functions of the Council. Chemists individually and as members of the different scientific societies were urged to co-operate with the Council in its efforts to visualize to the manufacturer the importance of industrial research. Prof. Arthur W. Thomas followed with some instructive remarks and a general review of recent developments in colloidal chemistry. Dr. Thomas exhibited a number of interesting colloids and by the use of an ultramicroscope demonstrated some of their unusual properties.

Invitation to Engineers to Visit Liége, Belgium, in 1922

The Association of Engineers graduated from the technical faculties of the University of Liége will celebrate next year the seventy-fifth anniversary of its founding. On this occasion there will be scientific ceremonials and social gatherings, to which will be invited the engineers of the great Belgian schools and of allied and friendly countries. The most important events will be a scientific congress and a technical exposition, June 11 to July 14, 1922.

The congress will include sections on mines, metallurgy, mechanics, electricity, chemical industries, geology and public works. The technical exposition will have for its aim the showing of the important rôle played by engineers in works of the profession and in industry.

Contract for German Potash Signed

Six large manufacturers of fertilizer, according to information reaching the United States Potash Producers' Association, have closed a contract for 80 per cent of their potash requirements for the next season with the German syndicate. The price is understood to be very close to the pre-war level. The closing of this contract, it was stated, leaves comparatively little business to be divided between the French and American producers. No American producer of potash is able to compete with the German product at the price offered. It was stated that they would not attempt to enter the market at the present price level.

The delay in the passage of the tariff bill is blamed by the domestic producers for this large contract going to Germany. They contend that they would have been able to meet the price of the German potash had the duty carried in the tariff bill been in effect.

Data Wanted on Industrial and Technical Photography

A survey of industrial and technical photography is being prepared by John H. Graff, industrial photographer and photomicroscopist, Brown Co., Berlin, N. H. In order to supplement his own wide experience with that of others in this field, Mr. Graff requests those using photography in their plants or organizations to assist him with samples of different types of photographs used; a short statement of how and why photography is being used, as in field, office, plant or research; information as to how far an outside photographer is employed, or, if the users have photographic departments of their own, a history of the development of the same. Methods of mounting, filing and reference are important; also statements of the costs and upkeeps of the departments and the value and importance of them.

All these data and information will be compiled to make a complete history of the development and uses of industrial photography.

Bureau of Mines Co-Operative Agreements

As co-operative agreements between the U. S. Bureau of Mines and outside agencies are terminated automatically at the end of each fiscal year, it is necessary to renew the agreements that are to be continued. Those thus far signed for the current fiscal year add more than $250,000 to the bureau's appropriations for research work. Of more importance, however, than the actual money made available are the contributions of services of technical men, of laboratories and other equipment. The co-operative agreements of direct interest to the chemical industries are:

University of Alabama—To study the problems peculiar to the mineral industry in the Southern States, particularly those relating to non-metallic minerals and their by-products, steel, coal and coke.

University of Arizona—To study problems connected with the mining and smelting of low-grade copper ores of the Southwest, with particular attention being paid to sulphur dioxide leaching and the precipitation of copper from sulphate solutions.

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University of California—To study problems including the purification of copper sulphate solutions, the fundamental chemistry of chloride volatilization and reduction of iron oxides with gases. The chemical service laboratory handles the chemical end of the work at the mining experiment stations located at Reno, Seattle and Salt Lake City.

State of Colorado—To make investigations and to secure data regarding the production of oil from oil shales.

Cornell University—To study alloys, principally those of the non-ferrous type, and electric furnaces.

Ohio State University—To study means of increasing efficiency in the utilization of the mineral substances necessary to the ceramic industry, and to study means of substituting ceramic products of American manufacture for those now imported.

University of Utah—To study the volatilization process as applied to low-grade lead and zinc ores in Utah and as applied to the reduction of lead fume and to the recovery of silver, lead and copper.

University of Washington—To study, among other things, the use of Northwestern clays for ceramic purposes and the electrometallurgical problems of the Pacific Northwest.

Arizona Copper Co.—To study problems relating to the leaching of partly oxidized copper ores.

Central of Georgia Railway Co.—To conduct investigation of Georgia kaolins, to determine their suitability for pottery and other ceramic purposes; to conduct investigations concerning the suitability of bauxite clays and bauxites for refractory or other purposes.

Davison Chemical Co.—To investigate the possibilities of obtaining more complete recoveries of light oil from coke-oven gas for the production of motor fuels.

Combustion Engineering Corporation, New York — To study the combustion of powdered fuels.

Morris P. Kirk, Harbor City, Cal.—To study volatilization of sliver and lead from ores, and the reduction of volatilized fume into metallic bullion.

Vanadium Corporation of America, New York—To investigate molybdenum steel.

The Welsbach Co., Gloucester City, N. J.—To investigate cerium alloys.

University of Montana—To study the industrial use of picric acid.

Fire Changes Paper Company's Water-Power Plans

On Saturday, Oct. 8, a fire of unknown origin destroyed the sawmill of I. M. Pierce & Co. at Orono, Me. Because of the distance the logs are now being driven, the mill will not be rebuilt near the present site. The sawmill, a very old one, became the property of the International Paper Co. a few years ago, as it desired to control the water at the mouth of the Stillwater River where it flows into the Penobscot. Arrangements were then made for the continuance of the sawmill, using steam and electric power, and the mill has been a busy place even during the recent depression.

The International Paper Co. uses the water for its Webster mill on the one bank of the river and for its mechanical pulp and hydro-electric plant on the other bank. With the elimination of the sawmill, it is now probable that the old log dam, which was already partly replaced by a higher concrete one at the flume intakes, will be extended across the river, allowing greater water storage and additional installation of pulp grinders and hydro-electric equipment.

The paper company began to operate one of the paper machines recently after being closed down since last spring by a strike. With the many men from the sawmill out of employment, it can be expected that many men from the paper mill, still on strike, will go back.

To Oppose Pollution Bill

Representatives of chemical industries will appear before the Committee on Rivers and Harbors of the House of Representatives on Oct. 25 to oppose a bill by Representative Appleby which, if passed, will make it illegal for manufacturing plants or ships to discharge oil and other refuse matter into any navigable waters of the United States. The passage of this bill, it is declared, would work the greatest hardship on a large number of chemical plants.

Civil Service Examination

Open competitive examinations are announced by the United States Civil Service Commission for the following positions: Metallurgist, $4,000 to $4,800 a year; associate metallurgist, $3,000 to $3,800; assistant metallurgist, $2,000 to $2,800; junior metallurgist, $1,500 to $1,800.

Applications on Form 2118 will be received until further notice. Papers will be rated beginning Nov. 1, and thereafter every two weeks until the close of the examinations.

Personal

HAROLD W. ABBOTT has resigned as technical supervisor at the Messena plant of the Aluminum Co. of America, to accept a similar position with the Stackpole Carbon Co., St. Marys, Pa.

JOHN BORG has been elected president of the Big Ledge Copper Co., New York, N. Y., and NELSON GRAY, vice-president and treasurer.

MIERS BUSCH, Philadelphia, Pa., a member of the firm of Shoemaker & Busch, has been elected a director of the Pennsylvania Salt Manufacturing Co., Philadelphia.

CHARLES E. CARPENTER, president of E. F. Houghton & Co., Philadelphia, Pa., addressed the Pittsburgh (Pa.) chapter of the American Society for Steel Treating at the Chatham Hotel, Pittsburgh, on Tuesday evening, Oct. 4.

E. M. A. CHANDLER, formerly with the Industrial Chemical Laboratories, Inc., of Hammond, Ind., has accepted a position on plant research work at the new North Chicago plant of the Abbott Laboratories.

DR. G. G. COLE, head of the chemistry department at Lynchburg College, Lynchburg, Va., has been elected a fellow of the American Association for the Advancement of Science. The honor has been accorded as the result of his extensive research work. He has been a member of the association for fourteen years.

DR. F. G. COTTRELL, head of the chemical activities of the National Research Council, sailed from France on Oct. 11. Dr. Cottrell has spent the summer studying various phases of the chemical industry in Europe.

OTTO EISENSCHIML, president of the Chicago Chemists Club, has just returned from an extended trip in Europe.

E. T. MARCEAU, chemical director of the N. K. Fairbank Co., has transferred his headquarters from Chicago to the New York office.

DR. JOHN MARTIN THOMAS was inaugurated president of the Pennsylvania State College, Oct. 14, at State College, Pa.

H. S. WITMER, who has been for several years in the chemical department of the N. K. Fairbank Co., in Chicago, has been given charge of the St. Louis branch factory.

The University of Maine, Orono, Me., has had the following recent changes in the chemistry departments: George Mervil Seeley, instructor, replacing L. J. Waldbauer, who has gone to McGill; Milton Roland Louria, instructor, replacing Norman F. Eberman, who has gone to Johns Hopkins; John Newell Crombie, instructor, replacing V. L. Kemmerer, who has gone to Thiel College.

Obituary

S. C. LINBARGER, for the past six years ceramic engineer of the Carborundum Co., Niagara Falls, N. Y., died at his home in that city on Saturday, Sept. 3, at the age of twenty-nine years. Mr. Linbarger was a very active member of the American Ceramic Society, at the time of his death being chairman of the committee on sections and divisions and president of the New York branch of the society. He was an authority in the field of refractories and abrasives, having developed the crucibles of graphite, clay and silicon carbide, carborundum saggers and made a number of other important discoveries.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, OCT. 17, 1921.

Trading in the chemical market during the past week has been somewhat spotty with intermittent periods of activity and dullness. There were few important developments uncovered, although the continued inquiry for miscellaneous products gave an encouraging aspect to the situation. Export shipments during the past few months on leading basic chemicals have shown a decided expansion and domestic buying has been well distributed among the various principal consumers.

CHEMICALS

Producers of *nitrate of potash* have reduced prices on the domestic refined material and are asking 7¾@8c. per lb. on the granular according to quantity. Prices on *bichromate of soda* showed a little firmer tendency and the market closed at 7¾@8c. per lb. for small quantities. There were a few sales recorded by second hands at 7¾c. per lb. The demand has shown a fair improvement during the past week and offerings have not been plentiful. Most dealers of *caustic potash* were asking 5¼c. per lb. for the 88-92 per cent imported material, although some sales were transacted down to 5c. per lb. While activity is not so general, as buyers have not been desirous to follow the advance, the market seems to be holding its own around recent advances. Most of the imported material recently shipped is reported sold on contract to large consuming interests. Sales of *solid caustic soda* were reported at $4 per 100 lb., while some odd lot business has gone through at $4.05@$4.15 per 100 lb. Inquiries are quite numerous in the market and the tone is holding quite firm. The export demand from South America has been very good and large tonnage sales were reported by several dealers. A good domestic demand is also recorded from leading consuming interests. At the works 3¼c. per lb., basis 60 per cent, is quoted for prompt shipment. Dealers of *nitrite of soda* are shading prices slightly in various quarters and small quantity business is reported at 6¼c. per lb., ex-store. In most directions 6¾@7c. was the prevailing quotation. The demand has not been active of late and this condition has stimulated competition among holders.

Manufacturers of *bleaching powder* continue to quote 2¼c. per lb. f.o.b. works for large drums in carload lots and report conditions extremely favorable. A few producers report production sold up for the next few weeks, while others are barely able to meet the daily requirements. Imported material is quoted at $1.90 per 100 lb. c.i.f. New York. Sales of light *soda ash* in single bags are being made at $2.10@$2.15 per 100 lb. Barrels are moving at $2.45@$2.50 per 100 lb. A good inquiry is noted around the trade and the market is holding quite firm at the above figures. Ash at the works was quoted at $1.60 per 100 lb., basis 48 per cent, in carload lots. Prices on spot *oxalic acid* are heard from 15½@16c. per lb. Sales were reported f.o.b. works at 15@15½c. per lb., depending upon the brand and quantity. Inquiries are reaching the market in moderate volume, but seem to be only for small-sized lots. Sales of carload quantities of *silicate of soda* are reported by producers at $2.90 per 100 lb., f.o.b. New York, for the 60 deg. Bé. The 40 deg. in drums is moving on the basis of 1c. per lb. in carload lots and up to 1¼c. in smaller quantities. Imported *sulphide of soda*, 60-62 per cent, has sold at 4½c. per lb. during the week. The broken material was quoted at 4¾c. per lb. Domestic producers quote the fused at 5@5½c. and the broken at 5½@5¾c. per lb., according to quantity. Crystals, 30 per cent, are quoted at 3¼c. per lb. for domestic material, while numerous lots of imported material for shipment have reached the market at 2¾c. per lb. c.i.f. New York. Leading producers of *borax* are making sales at 5½c. per lb. for carload lots and 5¾@6c. for smaller quantities, depending upon the brand

and seller. Producers of *Glaubers salt* report sales at 1½c. per lb. in bags and $1.65 per 100 lb. in barrels for large quantities. Sales of smaller lots in bags are reported at $1.75 per 100 lb. and $1.90 for barrels. Manufacturers of *zinc carbonate* are placing business at 16@18c. per lb., according to quantity. The inquiry is moderate, although a fair volume of small lot business is being recorded. The demand for *camphor* has shown improvement during the past week and the spot market has responded readily to the increased buying power. At the close prominent importers reported sales at 76c. per lb. for the Japanese gum and up to 77c. for odd lots.

Coal-Tar Products

Sales during the week in the coal-tar products industry have shown considerable improvement. Intermediates have been a shade better, but there still lacks the real snap to buying. Most consumers are merely covering current necessities and are operating in a conservative manner. Heavy resale stocks of naphthalene, phenol, beta-naphthol and aniline oil continue to depress any possible hope for recovery. The majority of the products tend more toward stabilization, although prices are not advancing. Competition still remains quite keen among second hands and manufacturers and quoted prices are seldom adhered to when firm orders are in the market. There are reports around the trade that slightly increased production of *benzene* will soon be available through the opening of a few more coke ovens. Production at present is far from normal and this slight addition will be welcome news to many consumers who are anxiously awaiting supplies. Inquiries from rubber and paint makers are quite numerous for benzene. Refiners are offering only for future delivery at 27@33c. per gal. Resale stocks are very difficult to locate and generally sell at 38@40c. per gal. Resellers of *phenol* have placed business at 8¼@8½c. per lb., but the general quotation heard is 9c. per lb. Government resellers still quote 12c. per lb. The demand for export is decidedly brighter. Stocks among second hands are large and considerable buying will have to be done before the market assumes a normal basis. Makers of *paranitraniline* are quoting 80c. per lb., although there are some who intimate that as low as 77c. per lb. would not be turned down on firm business. Resellers ask 77c., with sales at slightly lower levels recorded. Producers of dimethylaniline ask 45c. per lb., but sales among resellers have been made down to 41c. Inquiries seem to be more numerous than formerly and more active interest has taken place in the past few days. Sellers of *betanaphthol* show no disposition to quote below 31c. per lb., except on real round lot business. The demand shows signs of improvement and some fair selling was done during the week. The scarcity of benzene has forced some manufacturers to stop their production of *aniline oil* and the market has strengthened to some extent. Resale stocks, however, are quite heavy and considerable purchasing must be done before the market will show signs of any real strength. The general asking price is 18c. per lb., but there are confirmed reports of actual sales somewhat below this level. First hands quote *H acid* at $1.10 @$1.15 per lb., but some selling is said to have been done under the inside figure. The demand has shown a slight improvement and some fair selling was done during the week.

Vegetable Oils

With the market for castor seed firm, crushers of oil were holding out for 11c. per lb. on the U.S.P. quality in barrels and 10c. for the No. 3 technical grade. Offerings of *chinawood oil* on spot were scanty and prices at best were merely nominal, ranging from 15@16c. per lb. The inquiry on spot was confined to small quantity lots only. Futures closed firmer, importers asking as high as 14c. per lb. for November-December shipments from the Orient, c.i.f. New York in hardwood barrels. The market for *coconut oil* underwent practically little change. Ceylon style oil in New York was available at 8⅝c. per lb. in sellers' tanks, nearby positions, while on the coast 8¼c. represented the market on November forward business. Manila oil in bulk closed at 7⅞c. per lb. asked, coast basis, November-December shipment, with little interest shown by buyers at this figure. Ceylon style oil in barrels was generally quoted at 10c. per lb. spot New York, with Cochin style oil held at 10½@11c. per lb.

The St. Louis Market

St. Louis, Oct. 14, 1921.

There has been quite an improvement in the drug and chemical market during the past two weeks and from all indications this should continue. While orders are still small, they are more numerous. However, a slight increase in volume is perceptible.

Prices on a whole are firm and the general opinion is that they have now reached a level where they are no longer consistent with manufacturing costs and the tendency will be to advance rather than make reductions for the future.

Alkalis

Caustic soda remains in good demand, the price of $4 per 100 lb., basis 73 to 75 per cent solid, f.o.b. point of production. There has been no change in this item. *Soda ash* demand is still only fair, with manufacturers' market prevailing. *Bicarbonate of soda* and *sal soda* are moving slowly but with the *bicarbonate* the more active at $2.60 per 100 lb. in less than carlots.

Chemicals, Drugs and Pharmaceuticals

The second-hand market an *acetphenetidin* seems to have cleared and a fair volume of business is being transacted. *Ammonia water*, 26 deg., continues to move in a regular way. A heavy demand for *sulphate ammonium, pure granular*, is now being experienced and large stocks should be carried. *Benzene* is in sold up condition, with producers accepting business for only small quantities. No futures—ruling price 35c. to 40c. per gal. *Bismuth salts* are moving beyond manufacturers' expectations. The *bromide* situation is none the worse and prices are firm. *Caffeine* is beginning to open, but competition still remains keen. *Carbon bisulphide* demand very strong, with prices ranging from 8@10½c. per lb., depending upon quantities. *Carbon tetrachloride* demand is good owing to the substitution of this material for carbon bisulphide, with price remaining at 12c. During the past few weeks there has been a substantial increase in the demand for *ethers*. *Formaldehyde* is moving very well. There is quite a movement of *glycerophosphates*. *Hypo* is moving in a routine way. *Hypophosphites* are beginning to move quite freely, due to the approach of the fall season and the heavy demand for tonics in which these commodities are used. *Iodides* are in good demand, especially the *potash salts*, for which there is a very heavy demand, undoubtedly due to the fact that Government surplus stocks are now exhausted. *Saccharine* is moving pretty well. *Salicylates* have shown an increase lately. *Sulphur* remains in easy demand and firm price due to high freight rates. *Zinc oxide, lead free*, is selling at 8c., with demand light.

Acids

The heavy mineral acids are now moving in large volume owing to the fact that many steel mills are again in operation and in all probability this demand will increase. A fair amount of business is being transacted in *phosphoric acid*. *Pyrogallic acid* remains in good demand. A small increase in *tannic acid* inquiries is reported. *Acid tartaric* remains the same.

Vegetable Oils and Naval Stores

Castor oil continues in good demand with price firm at 11½c. in drums for No. 1 U.S.P. *Linseed oil* has declined to 73c., basis raw oil, ex-warehouse. The demand is for spot oil and in small quantities. *Turpentine* demand is routine, with prices fluctuating from 75@79c., ex-warehouse.

Paint Materials

The *lithopone* market is showing signs of life. Manufacturers are quoting 6¼c. in carlots and 6½c. in less than carlots at St. Louis. The recent drop in the price of floated *barytes* has stimulated the demand, which is now very strong. Price $23 per ton continues strong. *Red oxide* and *whiting* moving slowly, with nominal price prevailing.

The Iron and Steel Market

PITTSBURGH, OCT. 14, 1921.

A bit of a chill has crept over the iron and steel and allied industries in the past week or two. There is nothing to indicate that conditions have grown worse in any respect, or to make it propable either that prices are going to decline or production decrease. The new appraisal of the situation must be due to disappointment over expected further improvement not materializing.

From the monthly report of the American Iron and Steel Institute, giving the steel ingot production of thirty companies, it can be computed that production in September was at about 32 per cent of capacity, against about 30 per cent for August and 21 per cent for July. At the middle of July production must have been at about 19 per cent. The increase to an average of 30 per cent for August was quite satisfactory. Apparently it was dangerously encouraging, since September, following the midsummer period, could be expected to show a greater broadening in steel demand. September, however, has shown an operation, in steel production, at only about 32 per cent, while the rate now can scarcely be estimated at over 35 per cent.

STEEL PRICES

Superficially viewed, steel prices show distinct vagaries. Bars, shapes and plates show a firming up. Since the beginning of August it has not been particularly difficult to place an attractive order at about 1.60c.

Last month there were definite advances in both sheets and wire products, $5 a ton on all descriptions of sheets, $2 a ton on plain wire and $3 a ton on barb wire and nails. Each line shows a new development this week. In sheets the independents are announcing another advance, $5 a ton, effective not later than tomorrow. In wire products it develops that attractive orders can again be placed at the old prices ruling prior to Sept 12.

These movements seem rather confusing, but steel prices do not always move in direct harmony with the relation between the demand and the capacity to supply the demand. In bars, shapes and plates the demand has been light and is light. Mills allowed prices to go below cost of production, hoping to broaden the demand. Buyers have not responded, and now they are trying to get cost out of the little business that is available. In wire products specifications against the contracts booked prior to the advance are presumably somewhat unsatisfactory, hence some sellers are willing to make sales afresh at the old prices. In sheets the business booked before the advance of three or four weeks ago was in actual shipping orders, which are beginning to play out, and it may be inferred that the mills are trying the experiment of another advance, to encourage orders at present prices. As the sheet mills have been losing money, it is quite possible they will adhere to the advance now promised, and their allowing the market to get down to its low point last August, when their costs were somewhat higher than at present, may be explained away or left without explanation. Prices upon which the advance is to be predicated are 2.50c. for blue annealed sheets, 3c. for black and 4c for galvanized.

Demand for oil country goods has increased somewhat, this being attributed to recent advances in oil prices causing oil interests to plan some winter drilling, for which the material must be delivered in the next few weeks.

Railroads have announced reduction of 28 per cent in iron ore freight rates, effective Oct. 20, approximately equaling the 40 per cent advances of Aug. 26, 1920. As the furnaces have large piles of ore, the reduction does not involve an early reduction in the cost of producing pig iron. The railroads had their eyes on the fact that there is approximately 10,000,000 tons of ore on Lake Erie docks. Furnacemen feel that in the circumstances they have no occasion to reduce pig iron prices. They would welcome reductions in rates on coke and limestone, on which they are paying freight bills every day. Consumers of pig iron would welcome reductions in rates on pig iron, which is sold them f.o.b. furnace. Naturally the buying of pig iron is not stimulated, and the market is very quiet. The valley market is unchanged at $20 for bessemer, $19.25 to $20 for basic and $21 for foundry.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.40 – $0.45
Acetone	lb.	$0.12½ – $0.12½	.13 – .13½
Acid, acetic, 28 per cent	100 lbs.	2.75 – 3.00	3.25 – 3.50
Acetic, 56 per cent	100 lbs.	5.50 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10.50 – 11.00	11.25 – 10.50
Boric, crystals	lb.	12½ – 13	13½ – 14
Boric, powder	lb.	13 – 13½	14 – 14½
Citric	lb.	–	.45 – .47
Hydrochloric	100 lb.	1.25 – 1.50	1.60 – 1.75
Hydrofluoric, 52 per cent	lb.	12 – 12½	12½ – 13
Lactic, 44 per cent tech	lb.	09½ – 10	10½ – 12
Lactic, 22 per cent tech	lb.	04½ – 05½	.06 – .07
Molybdic, C.P	lb.	3.25 – 3.50	3.60 – 4.00
Muriatic, 20 deg. (see hydrochloric)		–	–
Nitric, 40 deg	lb.	06½ – 06½	06½ – .07
Nitric, 42 deg	lb.	06½ – 07	07½ – 07½
Oxalic, crystals	lb.	15½ – 16	16½ – 17
Phosphoric, 50 per cent solution	lb.	13 – 13½	14 – 18
Picric	lb.	.20 – .25	.27 – .35
Pyrogallic, resublimed	lb.	–	1.75 – 1.90
Sulphuric, 60 deg., tank cars	ton	–	11.00 – 12.00
Sulphuric, 60 deg., drums	ton	–	13.00 – 15.00
Sulphuric, 66 deg., tank cars	ton	17.00 – 18.00	–
Sulphuric, 66 deg., drums	ton	21.00 – 22.00	22.50 – 23.00
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	21.00 – 22.00	–
Sulphuric, fuming, 20 per cent (oleum) drums	ton	23.00 – 23.50	24.00 – 24.50
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31.00 – 32.00	33.00 – 34.00
Tannic, U. S. P	lb.	–	.75 – .85
Tannic (tech.)	lb.	.45 – .48	.50 – .55
Tartaric, imported crystals	lb.	–	.26 – .27
Tartaric acid, imported, powdered	lb.	–	.27½ – .28½
Tartaric acid, domestic	lb.	–	– .35
Tungstic, per lb. of WO	lb.	–	1.10 – 1.20
Alcohol, Ethyl	gal.	–	4.65 – 4.90
Alcohol, Methyl (see methanol)		–	–
Alcohol, denatured, 188 proof	gal.	–	.35 – .36
Alcohol, denatured, 190 proof	gal.	–	.37 – .38
Alum, ammonia, lump	lb.	03½ – 03½	.04 – .04½
Alum, potash, lump	lb.	03½ – .04	.04½ – .04½
Alum, chrome lump	lb.	.10 – .11	.11½ – .12
Aluminum sulphate, commercial	lb.	.01 – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .02½	.03 – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .07½	.08 – .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 – .32	.33 – .35
Ammonium carbonate, powder	lb.	.07 – .07½	.08 – .09
Ammonium chloride, granular (white salammoniac)	lb.	.06 – .06½	.06½ – .07
Ammonium chloride, granular (gray salammoniac)	lb.	.06½ – .07	.07½ – .08
Ammonium nitrate	lb.	.07½ – .07½	.07½ – .08½
Amylacetate	gal.	–	3.25 – 3.50
Amylacetate tech	gal.	–	2.50 – 3.00
Arsenic oxide, (white arsenic) powdered	lb.	.05 – .06	.06½ – .06½
Arsenic, sulphide, powdered (red arsenic)	lb.	.11 – .11½	.12 – .13
Barium chloride	ton	44.00 – 45.00	46.00 – 50.00
Barium dioxide (peroxide)	lb.	.20 – .21	.22 – .23
Barium nitrate	lb.	.07½ – .08	.08½ – .09
Barium sulphate (precip.) (blanc fixe)	lb.	.04 – .04½	.04½ – .05
Bleaching powder (see calc. hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.27 – .28	.28½ – .30
Calcium acetate	100 lbs.	2.00 – 2.05	–
Calcium carbide	lb.	.04½ – .04½	.05 – .05½
Calcium chloride, fused, lump	ton	23.50 – 24.00	24.50 – 25.50
Calcium chloride, granulated	lb.	.01½ – .02	.02½ – .02½
Calcium hypochloride (bleach'g powder)	100 lb.	2.50 – 2.60	2.70 – 3.25
Calcium peroxide	lb.	–	1.40 – 1.50
Calcium phosphate, tribasic	lb.	–	.15 – .16
Camphor	lb.	–	.76 – .77
Carbon bisulphide	lb.	.06½ – .06½	.07 – .07½
Carbon tetrachloride, drums	lb.	.10½ – .10½	.11 – .12
Carbonyl chloride, (phosgene)	lb.	–	.60 – .75
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 – .09	.09½ – .10
Chloroform	lb.	–	.40 – .43
Cobalt oxide	lb.	–	2.00 – 2.10
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.19 – .19½	.20 – .21
Copper cyanide	lb.	–	.50 – .62
Copper sulphate, crystals	lb.	.05 – .05½	.05½ – .06
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Ethyl Acetate Com. 85%	gal.	–	1.00 – 1.10
Ethyl Acetate pure (acetic ether, 98% to 100%)	lb.	–	.40 – .42
Formaldehyde, 40 per cent	lb.	.11½ – .12	.12½ – .13
Fusel oil, ref	gal.	–	3.25 – 3.75
Fusel oil, crude	gal.	–	1.75 – 2.00
Glauber's salt (see sodium sulphate)		–	–
Glycerine, C. P. drums extra	lb.	–	.14 – .15
Iodine, resublimed	lb.	–	3.50 – 3.60
Iron oxide, red	lb.	–	.10 – .20
Iron sulphate (copperas)	ton	18.00 – 19.00	20.00 – 23.00
Lead acetate	lb.	–	.10½ – .12½
Lead arsenate, paste	lb.	.09 – .09½	.10 – .11
Lead nitrate	lb.	–	.15 – .20
Litharge	lb.	.07½ – .08	.08½ – .09
Lithium carbonate	lb.	–	1.30 – 1.40
Magnesium carbonate, technical	lb.	.08 – .08½	.09 – .10
Magnesium sulphate, U. S. P	100 lb.	2.50 – 2.75	–
Magnesium sulphate, technical	100 lb.	–	1.10 – 1.75
Methanol, 95%	gal.	–	.66 – .68
Methanol, 97%	gal.	–	.70 – .72
Nickel salt, double	lb.	–	.12 – .12½
Nickel salt, single	lb.	–	.14 – .14½
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	.40 – .41	.42 – .45
Phosphorus, yellow	lb.	–	.30 – .35
Potassium bichromate	lb.	.11 – .11½	.11½ – .12

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$.... – $....	$0.25½–$0.28
Potassium bromide, granular	lb.	..... –	.14 – .20
Potassium carbonate, U. S. P.	lb.	.20 – .21	.22 – .25
Potassium carbonate, 80–85%	lb.	.04½– .04¾	.05 – .06
Potassium chlorate, crystals	lb.	.06½– 07	.07½– .10
Potassium cyanide	lb.	..... –	.26 – .28
Potassium hydroxide (caustic potash)	lb.	.05¼– .05½	.05½– .06
Potassium iodide	lb.	..... –	2.60 – 2.75
Potassium nitrate	lb.	.07¼– .07½	.08 – .09
Potassium permanganate	lb.	.20 – .21	.22 – .23
Potassium prussiate, red	lb.	.28 – .29	.29½– .30
Potassium prussiate, yellow	lb.	.20 – .20½	.21 – .22
Rochelle salts (see sodium potas. tartrate)	....	....	..... – .....
Salammoniac (see ammonium chloride)	....	....	..... – .....
Sal soda (see sodium carbonate)	....	..... –	..... – .....
Salt cake (bulk)	ton	..... –	17.00 –20.00
Silver cyanide	oz.	..... –	1.35 – 1.38
Silver nitrate	oz.	..... –	.46 – .47
Soda ash, light	100 lb.	2.10 – 2.15	2.20 – 2.50
Soda ash, dense	100 lb.	2.35 – 2.40	2.45 – 2.70
Sodium acetate	lb.	.04 – .04½	.04½– .05
Sodium bicarbonate	100 lb.	2.00 – 2.25	2.50 – 2.75
Sodium bichromate	lb.	.07½– .08	.08½– .08¾
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P.	lb.	.04½– .05	.05½– .06
Sodium borate (borax)	lb.	.05½– .06	.06½– .07
Sodium carbonate (sal soda)	100 lb.	1.75 – 1.90	2.00 – 2.25
Sodium chlorate	lb.	.07½– .07½	.08 – .08½
Sodium cyanide	lb.	.25 – .26	.27 – .30
Sodium fluoride	lb.	.10½– .11	.11½– .12
Sodium hydroxide (caustic soda)	100 lb.	4.05 – 4.15	4.20 – 4.75
Sodium hyposulphite	lb.	..... –	.03½– .03¾
Sodium nitrite	lb.	.06½– .06¾	.07 – .07½
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04½– .04¾	.04¾– .05¼
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.21 – .24
Sodium prussiate, yellow	lb.	.13 – .13½	.13½– .13¾
Sodium silicate, solution (40 deg.)	100 lb.	1.00 – 1.15	1.25 – 1.40
Sodium silicate, solution (60 deg.)	lb.	.02½– .03	.03¼– .03½
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.50 – 1.75	2.00 – 2.25
Sodium sulphide, fused, 60–62 per cent (conc.)	lb.	.04½– .04¾	.05 – .06
Sodium sulphite, crystals	lb.	.03½– .03¾	.03¾– .04
Strontium nitrate, powdered	lb.	.12 – .13	.13½– .20
Sulphur chloride, red	lb.	.05 – .05½	.05½– .06½
Sulphur, crude	ton	18.00 –20.00	..... – .....
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	..... –	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	..... –	2.00 – 2.75
Tin bichloride, 50 per cent	lb.	.18 – .19	..... – .....
Tin oxide	lb.	..... –	.38 – .40
Zinc carbonate, precipitate	lb.	.16 – .16½	.17 – .17½
Zinc chloride, gran.	lb.	.09¼– .09½	.10 – .11
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc dust	lb.	.11½– .11½	.11½– .12½
Zinc oxide, XX	lb.	.07½– .07½	.08 – .09
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.15 — $1.20
Alpha-naphthol, refined	lb.	1.25 — 1.30
Alpha-naphthylamine	lb.	.27 — .30
Aniline oil, drums extra	lb.	.17½— .20
Aniline salts	lb.	.24 — .26
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P.	lb.	1.25 — 1.35
Benzidine, base	lb.	.90 — 1.00
Benzidine sulphate	lb	.75 — .85
Benzoic acid, U.S.P.	lb.	.60 — .65
Benzoate of soda, U.S.P.	lb.	.52 — .55
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 — .32
Benzene, 90%, in drums (100 gal.)	gal.	.25 — .28
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.50 — 4.00
Beta-naphthol, sublimed	lb.	.70 — .75
Beta-naphthol, tech	lb.	.31 — .34
Beta-naphthyla mine, sublimed	lb.	1.75 — 1.85
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .17
Ortho-cresol, in drums (100 lb.)	lb.	.25 — .27
Cresylic acid, 97–99%, straw color, in drums	gal.	.70 — .80
Cresylic acid, 95-97%, dark, in drums	gal.	.65 — .70
Cresylic acid, 50%, first quality, drums	gal.	.45 — .50
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	1.00 — 1.15
Dimethylaniline	lb.	.41 — .50
Dinitrobenzene	lb.	.23 — .27
Dinitroclorbenzene	lb.	.23 — .25
Dinitronaphthalene	lb.	.30 — .35
Dinitrophenol	lb.	.35 — .40
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.30 — .35
Diphenylamine	lb.	.60 — .70
H-acid	lb.	1.10 — 1.20
Meta-phenylenediamine	lb.	1.15 — 1.20
Monochlorbenzene	lb.	.12 — .14
Monoethylaniline	lb.	1.60 — 1.70
Naphthalene crushed, in bbls.	lb.	.06½— .07½
Naphthalene, flake	lb.	.06½— .08
Naphthalene, balls	lb.	.08 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17
Ortho-amidophenol	lb.	3.00 — 3.10
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.75 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.20 — .25
Para-amidophenol, base	lb.	1.40 — 1.45
Para-amidophenol, HCl	lb.	1.70 — 1.80
Para-dichlorbenzene	lb.	.12 — .15
Paranitroaniline	lb.	.77 — .80
Para-nitrotoluene	lb.	.80 — .85
Para-phenylenediamine	lb.	1.70 — 1.75
Para-toluidine	lb.	1.25 — 1.40
Phthalic anhydride	lb.	.40 — .50
Phenol, U. S. P., drums	lb.	.08½— .10
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	1.50 — 1.60
Resorcinol, pure	lb.	2.00 — 2.25
Salicylic acid, tech., in bbls.	lb.	.18 — .20
Salicylic acid, U. S. P.	lb.	.19 — .22
Salol	lb.	.60 — .70
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 — .28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 — .16
Sulphanilic acid, crude	lb.	.27 — .30
Tolidine	lb.	1.30 — 1.35
Toluidine, mixed	lb.	.43 — .45
Toluene, in tank cars	gal.	.25 — .28
Toluene, in drums	gal.	.28 — .31
Xylidines, drums, 100 gal.	lb.	.40 — .45
Xylene, pure, in drums	gal.	.40 — .45
Xylene, pure, in tank cars	gal.	.45 — ....
Xylene, commercial, in drums, 100 gal.	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 — ....

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	$0.19 — $0.20
Beeswax, refined, dark	lb.	.24 — .25
Beeswax, refined, light	lb.	.28 — .30
Beeswax, white pure	lb.	.36 — .42
Candellila wax	lb.	.24 — .25
Carnauba, No. 1	lb.	.46 — .47
Carnauba, No. 2, North Country	lb.	.24 — .25
Carnauba, No. 3, North Country	lb.	.14½— .15
Japan	lb.	.22 — .23
Montan, crude	lb.	.05 — .05½
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.03½— .03¾
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.02 — ....
Paraffine waxes, refined, 118-120 m.p.	lb.	.03 — .03½
Paraffine waxes, refined, 125 m.p.	lb.	.03½— .03¾
Paraffine waxes, refined, 128-130 m.p.	lb.	.03¾— .04½
Paraffine waxes, refined, 133-135 m.p.	lb.	.04½— .05
Paraffine waxes, refined, 135-137 m.p.	lb.	.05½— .06
Stearic acid, single pressed	lb.	.09½— ....
Stearic acid, double pressed	lb.	.10½— ....
Stearic acid, triple pressed	lb.	.11 — .11¼

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.55 —	5.65
Rosin E-I	280 lb.	5.75 —	6.25
Rosin K-N	280 lb.	6.35 —	6.75
Rosin W. G.-W. W	280 lb.	6.90 —	7.40
Wood rosin, bbl.	280 lb.	6.25 —	.....
Spirits of turpentine	gal.	75½ —	.....
Wood turpentine, steam dist	gal.	.73 —	.....
Wood turpentine, dest. dist.	gal.	.72 —	.....
Pine tar pitch, bbl	200 lb.	..... —	6.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	..... —	11.00
Retort tar, bbl.	500 lb.	—	11.00
Rosin oil, first run	gal.	.35 —	.....
Rosin oil, second run	gal.	.37 —	.....
Rosin oil, third run	gal.	.44 —	.....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist.	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref.	gal.		.52

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.37
70-72 deg., steel bbls. (85 lb.)	gal.	.35
68-70 deg., steel bbls. (85 lb.)	gal.	.34
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

Fertilizers

Ammonium sulphate, bulk and d. bags	100 lb.	$2.15 —	2.50
Blood, dried, f.o.b., N. Y	unit	4.00	
Bone, 3 and 50, ground, raw	ton	30.00 —	32.00
Cyanamide, f.o.b. works	unit	4.50	
Fish scrap, dom., dried, f.o.b. works	unit	2.90 —	3.00
Nitrate soda	100 lb.	2.25 —	2.30
Tankage, high grade, f.o.b. Chicago	unit	3.00 —	3.10
Phosphate rock, f.o.b. mines, Florida pebble, 68-72 p.c.	ton	5.00 —	7.50
Tennessee, 78-80 p.c.	ton	8.00 —	9.00
Potassium muriate, 80 p.c.	ton	38.00 —	40.00
Potassium sulphate	unit	1.20 —	1.25

Crude Rubber

Para—Upriver fine	lb.	$0.21 —	.21½
Upriver coarse	lb.	.11½—	.12
Upriver caucho ball	lb.	.11½—	.12
Plantation—First latex crepe	lb.	.15½—	.15½
Ribbed smoked sheets	lb.	.15¼—	.15½
Brown crepe, thin, clean	lb.	.15 —	.....
Amber crepe No. 1	lb.	.17 —	.....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.10 —	$0.10½
Castor oil, AA, in bbls.	lb.	.11 —	.11½
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.14½—	.15
Cocoanut oil, Ceylon grade, in bbls.	lb.	.10 —	.10½
Cocoanut oil, Cochin grade, in bbls.	lb.	.10½—	.11
Corn oil, crude, in bbls.	lb.	.09 —	.09½
Cottonseed oil, crude (f. o. b. mill)	lb.	.07½—	.07½
Cottonseed oil, summer yellow	lb.	.09 —	.09½
Cottonseed oil, winter yellow	lb.	.09½—	.10

Linseed oil, raw, car lots (domestic)	gal.	.68 —	.69
Linseed oil, raw, tank cars (domestic)	gal.	.63 —	.64
Linseed oil, in 5-bbl lots (domestic)	gal.	.71 —	.72
Olive oil, Denatured	gal.	$1.15 —	$1.20
Palm, Lagos	lb.	.07½ —	.07¾
Palm, Niger	lb.	.06½ —	.06¾
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08 —	.09
Peanut oil, refined, in bbls	lb.	.11½ —	.11¾
Rapeseed oil, refined in bbls	gal.	.90 —	.91
Rapeseed oil, blown, in bbls	gal.	.92 —	.94
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08½ —	....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07½ —	....
FISH			
Light pressed menhaden	gal.	$0.40 —	...
Yellow bleached menhaden	gal.	.42 —	....
White bleached menhaden	gal.	.44 —	....
Blown menhaden	gal.	.48 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24.00 —	30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	20.00 —	24.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00 —	24.00
Barytes, crude, first grade, Missouri	net ton	7.00 —	....
Blanc fixe, dry	lb.	.04 —	.04½
Blanc fixe, pulp	net ton	45.00 —	55.00
Casein	lb.	.07 —	.10
Chalk, Precipitated, domestic, extra light	lb.	.04½ —	.05
Chalk, Precipitated, domestic, light	lb.	.04 —	.04½
Chalk, Precipitated, domestic, heavy	lb.	.03½ —	.04
Chalk, Precipitated, English, extra light	lb.	.04½ —	.05
Chalk, Precipitated, English, light	lb.	.04½ —	.05
Chalk, Precipitated, English, dense	lb.	.04 —	.04½
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50 —	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00 —	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00 —	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00 —	20.00
China clay (kaolin), imported, lump	net ton	12.00 —	20.00
China clay (kaolin), imported, powdered	net ton	25.00 —	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00 —	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00 —	30.00
Fullers earth, f.o.b. Mines	net ton	16.00 —	17.00
Fullers earth, granular, f.o.b. Pa	net ton	15.00 —	18.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00 —	....
Fullers earth, imported, powdered	net ton	24.00 —	27.00
Graphite, Ceylon lump, first quality	lb.	.06 —	.07
Graphite, Ceylon chip	lb.	.04½ —	.05
Graphite, high grade amorphous crude	lb.	.00½ —	.02½
Kieselguhr, f.o.b. mines, Cal	per ton	40.00 —	....
Kieselguhr, f.o.b. N.Y	per ton	61.00 —	....
Magnesite, calcined	per ton	66.00 —	70.00
Pumice stone, imported	lb.	.03 —	.40
Pumice stone, domestic, lump	lb.	.05 —	.05½
Pumice stone, domestic, ground	lb.	.06 —	.07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	..... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	..... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	..... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	.66 —	.68
Shellac, orange superfine	lb.	.70 —	.72
Shellac, A. C. garnet	lb.	.53 —	.55
Shellac, T. N.	lb.	.59 —	.61
Soapstone	ton	12.00 —	15.00
Sodium chloride	long ton	12.50 —	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50 —	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50 —	11.00
Talc, imported	ton	30.00 —	40.00
Talc, California talcum powder grade	ton	18.00 —	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton		$50.00
Carborundum refractory brick, 9-in. — less than carlot	1,000		1250.00
Carborundum refractory brick, 9-in. — carload lots	1,000		1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton		52- 55
Chrome cement, 40-45% Cr_2O_3	net ton		30- 32
Chrome cement, 40-45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton		33- 35
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		35- 40
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		30- 35
Magnesite brick, 9-in. straight	net ton		65- 70
Magnesite brick, 9-in. arches, wedges and keys	net ton		77
Magnesite brick, soaps and splits	net ton		98
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000		40- 42
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		42- 45
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		35- 38

Ferro-Alloys

All f.o.b. Works

Ferro-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.11 —	....
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.11 —	.12
Ferromanganese, 76-80% Mn, domestic	gross ton	60.00 —	63.00
Ferromanganese, 76-80% Mn, English & German	gross ton	59.00 —	60.00
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	60.00 —	65.00
Ferrosilicon, 75%	gross ton	130.00 —	135.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferrouranium, 35-50% of U, per lb. of U content	lb.	6.00 —	....
Ferrovanadium, 30-40% per lb. of contained V	lb.	4.25 —	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	24.00 —	26.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	24.00 —	26.00
Coke, foundry, f.o.b. ovens	net ton	4.25 —	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25 —	3.50
Coke, petroleum, refinery, Atlantic seaboard	net ton	12.00 —	13.00
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	15.00 —	.....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01½
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.20 —	.21
Manganese ore, chemical (MnO_2)	net ton	50.00 —	55.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.55 —	.60
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00 —	.....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	.....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.75 —	3.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	3.00 —	3.25
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.25 —	1.75
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	.....
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04½ —	.13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.00
Aluminum, 98 to 99 per cent	24.50@25.00
Antimony, wholesale lots, Chinese and Japanese	5.00@5.25
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, shot and blocks	35.00
Monel metal ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	27.25
Lead, New York, spot	4.70@4.75
Lead, E. St. Louis, spot	4.45@4.50
Zinc, spot, New York	5.05@5.10
Zinc, spot, E. St. Louis	4.65

OTHER METALS

Silver (commercial)	oz.	$0.72½
Cadmium	lb.	1.00–1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	80.00
Iridium	oz.	150.00@170.00
Palladium	oz.	55.00–60.00
Mercury	75 lb.	38.00–39.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	20.50
Copper bottoms	28.00
Copper rods	19.00@19.75
High brass wire	15.75
High brass rods	13.25
Low brass wire	17.25
Low brass rods	17.25
Brazed brass tubing	25.00
Brazed bronze tubing	23.75
Seamless copper tubing	19.50
Seamless high brass tubing	18.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.50@10.00	9.25	9.50
Copper, heavy and wire	9.00@9.25	8.50	8.50
Copper, light and bottoms	7.50@8.00	7.50	7.25
Lead, heavy	3.25@3.50	3.25	3.25
Lead, tea	2.25@2.35	2.25	2.25
Brass, heavy	4.25@4.50	4.50	5.00
Brass, light	3.25@3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@4.25	4.25	4.50
Zinc	2.00@2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.88	$2.88	$2.88
Soft steel bars	2.78	2.78	2.78
Soft steel bar shapes	2.78	2.78	2.78
Soft steel bands	3.42	3.48	3.48
Plates, ¼ to 1 in. thick	2.88	2.83	2.88

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arkansas

CAMDEN—The Camden Oil & Refining Co., recently organized, is perfecting plans for the construction of a new oil refinery in the vicinity of Pine Bluff, Ark., with initial daily output of about 500 bbl. It is estimated to cost about $40,000. H. M. Jones is president.

California

LOS ANGELES — The Bradley-Wise Paint Co., 650 Santa Fe Ave., manufacturer of paints, varnishes, etc., has awarded a contract to Gordon La Barr, 2000 East Vernon Ave., for the erection of its proposed new plant at 49th St. and the Pacific Blvd., Vernon, estimated to cost in excess of $50,000.

SAN FRANCISCO—The United States Metal Products Co., 330 Tenth St., manufacturer of metal specialties, has preliminary plans under way for the erection of a new 2- or 4-story plant, exact size still to be determined. It will be located on a site adjoining the present works.

Connecticut

WINDSOR LOCKS—C. H. Dexter & Sons, Inc., manufacturers of paper products, have taken bids for the erection of a new 1-story building at their plant, 21 x 140 ft. Greenwood & Noerr, 847 Main St., Hartford, Conn., are engineers.

Delaware

WILMINGTON — The Ricard-Brewster Oil Co. is completing the removal of its plant from Front and Orange Sts., to its new works at Fifteenth and Walnut Sts., where facilities for increased production will be provided. A 2-story brick addition has been constructed to the factory at the new location.

Florida

JACKSONVILLE—The American Collapsible Box Co., High Point, N. C. A. Vanden Boom, manager, is perfecting plans for the erection of its proposed new plant at Jacksonville, for the manufacture of corrugated boxes and containers. The machinery installation will cost about $75,000.

CANAL POINT—The Florida Sugar & Food Products Co. will soon commence the construction of its proposed new sugar mill, to be 100 x 200 ft., to be equipped for a daily production of about 400 tons of cane sugar. N. K. Williams is construction engineer in charge.

Louisiana

SHREVEPORT—The United States Window Glass Co., Morgantown, W. Va., has construction under way on the superstructure for its new local plant, estimated to cost in excess of $500,000, and plans to have the works ready for operation early in March, 1922.

MONROE — The McNichol Pottery & Crockery Co., Memphis, Tenn., J. M. Goff, representative, is considering the erection of a new plant in the vicinity of Monroe, estimated to cost in excess of $150,000 with machinery.

Maryland

HAGERSTOWN—The Vicama Mica Co., 3 Hamilton Row, recently incorporated, is planning for the installation of new equipment at its properties in Virginia, comprising quarrying machinery, pulverizing equipment and kindred apparatus for mica production.

Michigan

MARYSVILLE—The Transue Williams Steel Forge Corp. will defer the erection of its proposed new local plant, plans for which are nearing completion, until early in the coming year. The works are estimated to cost about $40,000. O. F. Transue, 562 West Ely St., is president and general manager.

DETROIT—The Solvay Process Co., Solvay, N. Y., is considering plans for the early reopening of its local plant. It is said that about 1,500 operatives will be employed at the start.

DETROIT—The Champion Porcelain Co., recently organized with a capital of $750,000 by officials of the Champion Spark Plug Co., as a subsidiary company, has acquired the plant and property of the Jeffrey-Dewitt Co., Detroit, manufacturer of porcelain specialties for spark plugs and other products. J. A. Jeffrey is president of the new company, and M. C. Dewitt, vice-president.

Missouri

KANSAS CITY—The Ferro Enamel Supply Co., 1101 Swetland Bldg., Cleveland, O., is considering preliminary plans for the erection of a new branch plant at Kansas City. R. A. Weaver is president.

ST. LOUIS—Fire, Oct. 5, damaged a portion of the building occupied by the Cole Chemical Co., on Laclede Ave. An official estimate of loss has not been made.

New Jersey

NEWARK—The United Butchers' Stock Rendering Co., 392 Jackson Ave., Jersey City, N. J., will take bids during the present month for the erection of its proposed new plant on property recently acquired at Newark, for the manufacture of soap, fertilizer and kindred products. It will be 2-story, 40 x 60 ft., and is estimated to cost about $50,000 with equipment. David M. Ach, 1 Madison Ave., New York, is architect.

NEWARK—The United Color & Pigment Co., McClellan St. and Evergreen Ave., has filed plans for improvements and alterations in its plant, used for the manufacture of paints, dry colors, etc., estimated to cost about $10,000.

New York

MECHANICSVILLE—The Duffney Brick Co., is having plans prepared for the erection of a new plant, with main building 2-story, brick and steel, to replace its works recently destroyed by fire, with loss reported at about $200,000. Bayard & Massey, 75½ North Main St., are architects.

SYRACUSE—The Solvay Process Co., Solvay, has adopted 24-hour operating basis at its local works, with total production said to be in excess of that during the war period.

BINGHAMTON—The Achilles Tire & Rubber Co., Floral Ave., has awarded a contract to S. B. Price for improvements in its plant, replacing a recent fire loss, estimated to cost about $15,000.

NEW YORK—The Fleischmann Co., 701 Washington St., manufacturer of yeast, will make extensions and improvements in its local plant, including laboratory, estimated to cost about $35,000. C. Aubrey Jackson, company address, is architect.

Ohio

ELYRIA—The Waukon Rubber Co. is completing plans and will take bids at an early date for the erection of a new 2-story and basement plant for the manufacture of rubber goods, estimated to cost about $75,000. The Akron Engineering Co., 92 East Mill St., Akron, O., is engineer. W. R. Huntington is president.

ZANESVILLE — The Studebaker-Wulff Co. is negotiating with the stockholders of the Rotary Tire & Rubber Co., now in receivership, for the purchase of the plant and property of the company.

Oklahoma

ARDMORE—The Magnolia Petroleum Co., Dallas, Tex., is planning for the erection of a new casinghead gasoline plant at Ardmore, to be of five-unit type, with power house, air compressors, pumping equipment, etc.

Pennsylvania

WILLIAMSPORT—Dittmar Bros., 618 Day St., manufacturers of composition tiles and kindred products, have broken ground for the erection of a new 2-story plant, 57 x 184 ft., at the foot of Susquehanna St., estimated to cost about $45,000. William Dittmar is head.

PHILADELPHIA—Fire, Sept. 30, destroyed a portion of the plant of the Publicker Commercial Alcohol Co., Swanson & Snyder Sts. An official estimate of loss has not been made.

South Carolina

CHARLESTON—Fire, Sept. 27, destroyed a portion of the local plant of the Virginia-Carolina Chemical Co., with loss estimated at about $27,000.

Tennessee

KNOXVILLE—The Knoxville Paper Box Co. has awarded a contract to Warsham Bros., Knoxville, for the erection of a new 1-story plant, 50 x 125 ft., for the manufacture of paper boxes and containers, estimated to cost about $35,000.

MEMPHIS—Fire, Oct. 4, destroyed a portion of the potash manufacturing plant of G. N. Shepardson, North Seventh St., with loss estimated at close to $25,000.

KNOXVILLE—The Knoxville Fertilizer Co. is perfecting plans for the erection of a new plant in the Vestal section, to be 154 x 350 ft. and equipped for an initial capacity of about 125 tons. Manley & Young, 814 West Hill Ave., are architects and engineers. James W. Dean is secretary and treasurer.

BROWNSVILLE—The Brownsville Cotton Oil Co. is planning for the rebuilding of the portion of its plant, recently destroyed by fire with loss estimated at about $22,000. R. N. Bond is manager.

Texas

DALLAS—The Trinity Oil Corp. will commence work at once for the conversion of the skimming plant of the Eastland Oil & Refining Co., into a complete oil refinery and purposes to have the plant ready for operation early in the coming year, with capacity of about 4,000 bbl. a day. The Eastland properties were recently acquired by the Trinity Company.

HOUSTON—The Sinclair Refining Co. is planning for the construction of a new battery of high-pressure oil stills and auxiliary operating equipment on the Houston Ship Channel.

BURKBURNETT—The Texas Oil Refining Co. is planning for the rebuilding of the portion of its local plant, destroyed by fire, Sept. 17, with loss approximating $30,000.

Virginia

NORFOLK—The Tidewater Glass Mfg. Co. has arranged for the immediate erection of a new 1-story plant, 50 x 200 ft., for the manufacture of glass bottles, and will take bids until Nov. 1 for the installation of equipment, including blowing machines, air compressor, motors and other manufacturing and operating machinery. T. C. Williams is vice-president and architect in charge. J. L. Welton is president.

West Virginia

WHEELING—The Bonita Art Glass Co. is completing plans for the erection of its proposed new plant, comprising two 1-story buildings, 60 x 80 ft., estimated to cost about $35,000. George E. House is president.

New Companies

E. L. & J. F. DENNEBY, INC., Brockton, Mass., has been incorporated with a capital of $25,000, to manufacture polishes for leather of all kinds, and kindred specialties. Edward L. Denneby is president, and James F. Denneby, 98 Warren St., treasurer.

THE LAKANTYSAS OIL CO., Room 800, 108 South La Salle St., Chicago, Ill., has been incorporated with a capital of $1,500,000, to manufacture petroleum products. The incorporators are Paul N. Dale, C. C. Taylor and Eric L. Anderson.

THE STENNO CARBON PAPER CO., Salem, Ore., has been incorporated with a capital of $150,000, to manufacture carbon and waxed papers and kindred products. The incorporators are F. E. Thompson, C. K. Bland and F. H. Drake, all of Portland, Ore.

THE MARYLAND SOAP CO., INC., Baltimore, Md., has been incorporated under Delaware laws with capital of $500,000, to manufacture soaps, soap powders, etc. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington, Del.

THE ROCHESTER PETROLEUM PRODUCTS, INC., Rochester, N. Y., has been incorporated with a capital of $50,000, to manufacture oil products of various kinds. The incorporators are T. M. Jameson, C. H. Miller and H. G. Freeman, Rochester. The

company is represented by Theodore Jameson, Wilder Bldg.

THE RHODE ISLAND CRUCIBLE STEEL CO., Providence, R. I., has been incorporated with a capital of $100,000, to manufacture steel products, castings, etc. The incorporators are George C. Hagstrom, Albert B. Benson and Carl A. Hagstrom, 185 Oakhill Ave., Pawtucket, R. I.

THE FIBRE TIRE & RUBBER CORP., New York, N. Y., has been incorporated under Delaware laws with capital of $3,000,000, to manufacture rubber products, fiber specialties, etc. The company is represented by Arthur W. Britton, 65 Cedar St., New York.

THE MINERAL CARBONIC GAS CO., Jersey City, N. J., has been incorporated with a capital of $200,000, to manufacture carbonic gas and affiliated products. The incorporators are H. W. F. Lorenz, Alexander Hynd and William Hall, 164 Broadway, Jersey City.

THE ATLAS CLAY PRODUCTS CO., INC., Atlas (Genesee Co.), Mich., has been incorporated with a capital of $30,000, to manufacture burned clay products. The incorporators are W. T. Shonk, Redford, Mich.; and M. B. Goodrich, 1090 Sheridan Ave., Detroit, Mich.

THE WATERPROOFING CO. OF AMERICA, INC., 80 East Jackson Blvd., Chicago, Ill., has been incorporated with a capital of $25,000, to manufacture waterproofing compounds and kindred specialties. The incorporators are A. N. Lustig, M. M. Rappaport and Fred Sprinkman, Jr.

MCLANE BROS., MCCARTHY & SHEEHAN, INC., Whitman, Mass., has been incorporated with a capital of $60,000, to manufacture leather products. The incorporators are William T. McLane, James J. Sheehan and Philip M. McLane, Abington, Mass.

THE LUSTRE ART GLASS CO., New York, N. Y., has been incorporated with a capital of $50,000, to manufacture glass products. The incorporators are P. Frank, C. Vahlsing and W. S. Overend, 34 Nassau St.

THE FENG LABORATORIES, INC., New York, N. Y., has been incorporated with a capital of $5,000, to manufacture chemical specialties. The incorporators are A. Lapidus, L. Weinstein and M. Lindeman. The company is represented by Fowler & Hoerner, 27 Cedar St.

THE PHILADELPHIA VINEGAR CO., Philadelphia, Pa., has been incorporated with a capital of 2,000 shares of stock, no par value, to manufacture vinegar and affiliated products. The company is represented by the New Jersey Corp., Guarantee & Trust Co., 419 Market St., Camden, N. J.

THE CHERRY RIDGE BRICK CORP., New York, N. Y., has been incorporated with a capital of $25,000, to manufacture brick and other burned clay products. The incorporators are G. Stewart, J. W. Collopy, Jr., and A. R. Prendergast. The company is represented by John Ingle, Jr., 2 Rector St.

THE FRENCH-WITTUSEN CO., INC., Utica, N. Y., has been incorporated with a capital of $25,000, to manufacture glassware products. The incorporators are W. S., G. B., and M. M. French, Utica. The company is represented by Colegrove & Baker, attorneys, Utica.

THE ANTI-GLARE ACCESSORIES CO., Indianapolis, Ind., has been incorporated with a capital of $20,000, to manufacture light diffusers, glass specialties, etc. The incorporators are F. G. Phillips, M. D. Moore and W. E. Miller, all of Indianapolis.

THE CYL-LAP PRODUCTS CO., Baltimore, Md., has been incorporated with a capital of $1,500,000, to manufacture abrasive products. The incorporators are Michael S. Coan, David L. Schiller and Robert F. Leach, Jr., Central Savings Bank Bldg.

THE PAN-AMERICAN CANADIAN LEATHER PRODUCTS CORP., Rochester, N. Y., has been incorporated with a capital of $4,500,000, to manufacture leather products. D. Colbert, 51 Vick Park, Rochester, is the principal incorporator.

THE STATE OIL PRODUCING CO., Boston, Mass., has been incorporated under Delaware laws with a capital of $300,000, to manufacture oil products. The incorporators are Willard Wayne, M. A. Colter and Henry C. DeWolf, Boston. The company is represented by the Delaware Trust Co., 900 Market St., Wilmington, Del.

THE NORTH AMERICAN POLISH CO., Los Angeles, Cal., has been incorporated with a nominal capital of $5,000, to manufacture polishes, chemical products and kindred specialties. The incorporators are S. P. and B. B. Dorsey, and W. B. French, Pasadena, Cal. The company is represented by Ticknor, Carter & Webster, 304 Citizens Savings Bank Bldg., Pasadena.

Manufacturers' Catalogs

THE YOUNGSTOWN BOILER & TANK CO., Youngstown, O., calls attention to a well-illustrated bulletin, No. 400, printed in colors, which contains storage tank information, tables, designs and capacities.

THE NORTON CO., Worcester, Mass., has issued a 32-page booklet on Norton grinding machines. A general description is given, together with photographs of the different types.

THE CHAMPION ENGINEERING CO., Kenton, O., in a recent bulletin illustrates and describes its cranes, suitable for installation in foundries, fertilizer plants, tin plate mills, chemical plants, rubber and tire plants, sugar cane mills, copper smelting plants, etc. Mechanical data are given, together with photographs of cranes in operation in different industries and dimensions of the different types.

THE KING KNIGHT CO., San Francisco, Cal., calls attention to its publication "Oil Flow in Pipe Lines," by R. S. Danforth. This book comprises charts showing the pressure loss in different sized pipe lines, the conversion of viscosimeter readings, and the horsepower required for pumping. Price $3.

BAKER & CO., INC., Newark, N. J., has issued the fourteenth edition of a booklet, Data Concerning Platinum, containing new tables, illustrations and matter descriptive of various appliances made of platinum.

THE M. W. KELLOGG CO., New York, N. Y., has issued an attractive booklet on Corrosion Tests, Grey Cast Iron and Chemi-Steel. Fifteen tests are described, together with a story on forge-welded chemi-steel and its industrial applications.

E. C. CODD CO., Baltimore, Md., in a new booklet describes chain furnace screens for furnaces and ovens. These screens consist of a multitude of individual strands of steel chain, which cuts off most of the heat rays but which does not interfere with the passage of the charge, nor the tools necessary for manipulation of the same.

THE HARDINGE CO., New York, N. Y., has issued Catalog 9, on "Pulverized Fuels." This bulletin is divided into three main sections—viz., the application of pulverized fuel to various burning problems, the principle of operation of the Hardinge mill and a discussion of the application of the Hardinge system for pulverizing fuels. This bulletin should be of interest to those who have problems pertaining to the generation large quantities of heat.

THE KINITE CO., Milwaukee, Wis., in a 24-page booklet describes and illustrates the use of Kinite for shear blades, redrawing tools, blanking dies, draw dies, embossing and forming dies, broaches, etc. Kinite is explained to be a steel alloy having great resistance to wear, dense structure and close grain, air-hardening quality, freedom from distortion when hardening, and ability to take high polish.

THE LAKEWOOD ENGINEERING CO., Cleveland, O., in Bulletin 39 illustrates and describes Lakewood Model 701, storage battery tractor.

THE POWER SPECIALTY CO., New York, has just published a 32-page catalog on Superheated Steam and the Foster Superheater. In the fore part of this bulletin there is a discussion of the advantages of using superheated steam. This covers the benefits and savings to be expected with superheated steam on reciprocating engines and steam turbines. The Foster patented superheater construction is also fully explained and pictures and drawings are shown of modern installations of this superheater in all well-known types and makes of boilers. This same bulletin also introduces a new type of superheater which utilizes radiant heat from the combustion chamber of the boiler. A new special armored surface has made it possible to apply superheating elements of this kind to any type of water-tube boiler. The construction and advantages of this type are fully covered in the new bulletin No. 300.

THE PHILADELPHIA DRYING MACHINERY CO., Philadelphia, Pa., has just issued a new folder, which briefly illustrates and describes all the different types of ceramic and chemical driers this company builds.

THE DANIEL M. LUEHRS CO., engineer, Cleveland, O., has issued a bulletin on the Luehrs System of Liquid Heat Transmission. The system applies best in the form of circulating oil, heated electrically, where temperatures higher than steam are needed and where the application of direct heat would injure the product or be dangerous to apply. Automatic temperature control is provided. Another bulletin describes the system applied to oil roasting of food products, etc.

Capital Increases, Etc.

THE SUPERIOR ALUM WORKS, INC., Joliet, Ill., has filed notice of change of name to the Superior Chemical Co.

THE MERIDAN OIL CO., Indianapolis, Ind., has filed notice of dissolution under state laws.

THE BEAVER TILE & SPECIALTY CO., 442 West 42d St., New York, N. Y., is arranging for an increase in capital from $45,000 to $200,000. George B. Staples is president.

THE L. P. C. CHEMICAL CORP., a Delaware corporation, has filed notice to operate in New York, with capital of $500,000, for the manufacture of chemical products. F. S. Mardon, 416 East 57th St., New York, is representative.

Involuntary bankruptcy proceedings have been instituted against the VALLEY FORGE MAGNESIA CO., Port Kennedy, Pa., manufacturer of magnesia products.

THE NAVAJO OIL CORP., Kansas City, Mo., has filed notice of change of name to the Interstate Refineries, Inc.

THE ZENITH FOUNDRY CO., Detroit, Mich., has filed notice of increase in capital from $125,000 to $200,000.

THE SCOVILL MFG. CO., Waterbury, Conn., manufacturer of brass products, has arranged for an increase in capital from $5,000,000 to $20,000,000.

THE AMERICAN AMMONIA CO., Boston, Mass., a Delaware corporation, has filed notice of increase in capital from $950,000 to $1,200,000.

Paul S. Ache, Erie Pa., has been appointed receiver for the CHIPPEWA OIL & REFINING CO., Beaver, Pa., in bond of $50,000. The company's refinery will be continued in operation.

THE AMERICAN CORK SPECIALTY CO. and the COMPRESSED CORK CO., 461 Eighth Ave., New York, N. Y., have been merged with L. Mundet & Son, same address, manufacturer of kindred cork products.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its seventy-fourth meeting at Toronto, Canada, Dec. 27 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-first annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN GAS ASSOCIATION will hold its third annual convention in the Congress and Auditorium Hotels, Chicago, the week of Nov. 7. More than 100 manufacturers will exhibit their latest gas-burning appliances.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its annual winter meeting at Baltimore, Md., Dec. 6 to 9. Headquarters will be at the Southern Hotel and the sessions will be held in the Engineers' Club.

AMERICAN MINING CONGRESS AND NATIONAL EXPOSITION OF MINES AND MINING EQUIPMENT is holding its twenty-fourth annual convention in the Coliseum, Chicago, Oct. 17 to 22.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS will hold its thirty-eighth annual convention at the Washington Hotel, Washington, D. C., Oct. 24-26.

INDUSTRIAL COST ASSOCIATION will hold its second national conference at Pittsburgh, Pa., Nov. 2-4, with headquarters at the William Penn Hotel.

INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA will hold its annual convention at the Waldorf-Astoria, New York, Nov. 1-5.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Oct. 21—Society of Chemical Industry, Grasselli Medal; Nov. 11—American Chemical Society (in charge), Society of Chemical Industry, American Electrochemical Society, Société de Chimie Industrielle joint meeting; Nov. 18—American Electrochemical Society, regular meeting; Dec. 2—Society of Chemical Industry, regular meeting; Dec. 9—American Chemical Society regular meeting.